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NOV 30 1921

ENGINEERING:

Engineering Library

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXII.—No. 2916.] *LONDON: FRIDAY, NOVEMBER* 18, 1921. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd.,
ROCHESTER.
9037

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 29 and 79.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2.
See half-page Advert. last week and next week. 9389

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9109

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 105.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9063

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9105

Cochran Boilers.
MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 9108

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 2½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 10 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Electric Transporters.
S. H. HEYWOOD & CO., LTD., REDDISH. 9026

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
1834
11, BILLITER SQUARE, E.C.3.

Iron and Steel
Tubes and Fittings.
Sole Licencees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 85, Nov. 11.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull," 9762

Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL; and MESSRS. BUCKNALL & RICHES, 8, SOUTHAMPTON ROW, LONDON, W.C. 1. Telephone No.: Museum 6084. 4078
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 111, last week.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS. MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Od 8353
3, VICTORIA STREET, WESTMINSTER, S.W.

Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 8134
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Lifts
(UP TO 35 TONS.)
9026
S. H. HEYWOOD & CO., LTD. REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9364
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 93. 9091

Machine and Engineering
WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, LTD., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E. 15. 1794

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW, LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 9241

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od3382

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
300, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7424. Od 585

CHANTIERS & ATELIERS.
Augustin-Normand
61, rue de Perrey—LE HAVRE (France). 3890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Cranes.
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

The National Foremen's
ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.
(Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. F 601
All communications to— H. W. REID, General Secretary.
Head Offices— 95, Belgrave Road, Victoria, London, S.W.1.

Bull Head Rails,
Second-hand
M. R. 85 lbs. section
250 tons FOR SALE,
8,000 SLEEPERS, Chairs, Fishplates, etc.,
THOS. W. WARD, LTD.,
Sheffield. S 435

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Yarrow Patent Water-tube Boilers.
9364
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9418
See Full Page Advt., page 72, Nov. 11.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Spur & Bevel Gear Generating
ATTACHMENTS FOR SHAPERS.
Spur Gear 12 in. Straight & Spiral Bevels 6 in. and 9 in. Through Merchants only. 9704
MATTERSON, LIMITED, Shawclough, Rochdale.

"Delta Brand" HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 9080
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Taylor & Challen Presses
9196
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 68, Oct. 14.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9074

"Spencer-Hopwood" Patent WATER TUBE Boilers. *See page* 103 9296
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"**
9505
E. G. Acheson Ltd.,
Dept. R., 40, WOOD ST., S.W.1. (Sole Manufacturers.) Works: PLYMOUTH.

Locomotive Traversers
(ELECTRIC).
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 139, Trongate, GLASGOW. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9727
See half-page Advertisement page 73, Oct. 28.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

Correspondence Courses for B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. Trevor W. Phillips, B.Sc. (Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., M.B.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9814

Inst. C.E. Exams.—Successes as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of Engineering.

Iron and Steel Institute. 28, Victoria Street, London, S.W. 1.

ANDREW CARNEGIE RESEARCH FUND.

The COUNCIL of the IRON AND STEEL INSTITUTE is PREPARED to RECEIVE APPLICATIONS for GRANTS in aid of research work on the metallurgy of iron and steel.

The number of grants in any one year is limited to five or six. The Council is not pledged to accept any particular application for assistance, but will give preference to those proposals which appear to them to be of the most practical advantage to the iron and steel and allied industries.

Proposals should be submitted before the end of February, 1922, on a special form to be obtained from the SECRETARY of the Institute. S 646

TENDERS.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—

LATHES.

Forms of Tender may be obtained from the Director General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m., on Thursday, the 8th December, 1921.

T. RYAN,
Director-General. S 640

WREXHAM AND EAST DENBIGHSHIRE WATER CO.

SUPPLY OF 12-inch DIAMETER STEEL TUBES.

The Directors invite

Tenders for the Supply and

DELIVERY of approximately 18,000 ft. of 12-in. STEEL TUBES, with Spigot and Socket ends.

Full particulars may be obtained on application to the undersigned. Sealed Tenders, endorsed "Tender for 12 in. Steel Tubes," to be delivered at the Offices of the Company, Egerton Street, Wrexham, not later than 1st December next.

The Company do not bind themselves to accept the lowest or any Tender.

FREDERICK STORR,
Engineer and Secretary.

Water Offices,
Egerton Street, Wrexham.
8th November, 1921. S 553

ABERDEEN CORPORATION WATERWORKS. EXTENSIONS 1920.

CONTRACTS Nos. 4 & 5.—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into Contracts for the CONSTRUCTION of (a) about ¾ mile of 4-feet CONDUIT, partly in tunnel; (b) about ¼ mile of 4-feet CONDUIT.

The Drawings may be inspected, and Specifications, Schedules of Quantities and Forms of Tender obtained on and after 21st November, 1921, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen.

For each Specification of each contract a deposit of Five Pounds Sterling in cash will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona-fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities and other Schedules fully priced out in detail and shall not have withdrawn the same. Provision is made for adjustment of the contract sum to meet alterations in the cost of labour and materials.

Tenders on the forms prescribed and enclosed in securely sealed envelopes endorsed "Tender for New Aqueduct" and addressed to the Undersigned, must be delivered not later than 9th December, 1921.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.I.Mech.E.,
Water Engineer.

Water Engineer's Office,
41½ Union Street,
Aberdeen, 9th November, 1921. S 575

TO CONTRACTORS ONLY.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, &c., are prepared to receive—

Tenders before 11 a.m.

on Tuesday, 6th December, 1921, for the SUPPLY of—

1. ELECTRICAL
2. MECHANICAL

ENGINEERING LABOUR IN DAYWORK in connection with the Maintenance, &c., of installations in the Birmingham, Bristol and Liverpool Districts during the period of One Year from 1st January, 1922.

Forms of Tender and all particulars may be obtained on application to the CONTRACTS BRANCH, H.M. Office of Works, London, S.W. 1. S 599

CITY OF NOTTINGHAM.

THE WORKS AND WAYS COMMITTEE are prepared to receive

Tenders for the Supply of the

undermentioned STORES and MATERIALS, the Contracts to commence on the 1st January next, and to terminate on the 30th June, 1922.

A. Cement.
B. Blue Lias Lime.
C. Red Bricks.
D. Blue Bricks.
E. Timber.
F. Stoneware Pipes, etc.
G. Stoneware Pipes, etc. (patent joints).
H. Iron Castings, Iron Gulleys, etc.
I. Yorkshire Flags, Kerb, etc.
J. Granite Setts, Kerb, and Broken Granite.
K. Ironstone Slag, Chippings, etc.
L. River Gravel.
N. Picks, Shovels, Scoops, etc.
O. Ironmongery.
P. Scavenging and other Brushes.
Q. Disinfectants.
R. Refined Tar.
S. Pitch.
T. Creosote Oil.

Forms of Tender may be obtained on applying to Mr. T. Wallis Gordon, Acting City Engineer, Guildhall, Nottingham, on payment of a deposit of 5/- each, which will be returned on receipt of a bona-fide Tender in accordance with the Specifications, providing such Tender is not withdrawn and is delivered by the time stated below.

Patterns and Samples may be inspected at the Eastcroft Depôt, London Road, Nottingham.

The Committee will not consider any Tender except on the authorised form of Tender, which must be delivered to the undersigned, in the official envelope provided, on or before Thursday, 8th December, 1921.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be accepted from persons who conform to the conditions as regards paying the local standard rate of wages, etc., and to the working rules of the Nottingham District applicable to the various trades.

By Order,
W. J. BOARD, Town Clerk.

Guildhall, Nottingham.
14th November, 1921. S 624

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND).

CONTRACTS 1922.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Three Months commencing 1st January, 1922, and alternatively for Six Months commencing the same date.

	No. of Form.		No. of Form.
Acid, Sulphuric ...	3D	Glass and China Sundries	27D
Asbestos Sheeting, etc.	40	Hardware (Sundry)	17
Baskets	10	India Rubber Goods	9A
Bolts, Nuts and Rivets	15	Implements, Sundry	21
Brooms and Brushes	13	Iron Tubes and Fittings	29
Brass Fittings for Carriages	18	Iron and Steel Wire	30A
Do. do. for Lamps	18A	Leather	12
Do. do. for Water	26A	Linen	8
Do. do. for Gas ...	26B	Locks and Keys ...	19
Canvas and Sacks ...	6	Mats, Fibre	10
Carriage Laces ...	7A	Nails	31
Castings, Mall. Iron	11	Oak Keys	35A
Cloth for Carriages and Uniforms ...	7C	Oak Trenails	35B
Clothing, Oil... ...	9B	Packings	40
Do. I.B. proofed ...	9B	Plumbago	41
Coach Screws and Washers	15	Railway Fastenings (Iron) ...	16
Colours	2	Do. (Steel)... ...	16A
Corks	39	Rain Water Pipes and Gutters	25
Cotton Waste ...	5A	Ropes, Twine, & Flax	4
Crucibles	41	Sewer Pipes, Plaster of Paris, etc. ...	32
Drysalteries	3	Shovels, Spades, etc.	21A
Emery and Glass Cloth, etc.	28	Soft Goods	8
Files and Tool Steel	20	Sponge Cloths ...	5
Fire Bricks and Clay	33	Signal Wire Pulleys	11
Foundry Requisites	42	Screws and Split Pins	14
Galvanized Sheets, Buckets, etc. ...	23	Tin Plates	22
Grates, Stoves and Fenders	24	Waste	5A
Grindstones	28	Waterproof Clothing	9B
Glass, Sheet, and Plate	27A	Wicks	5
		Wire, Fence and Signal	30A
		Wirework	30B

Forms of Tender can be obtained on PAYMENT of 1s. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department on and after the 18th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m. on Wednesday, 30th November, 1921.

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
ROBERT CRAWFORD, Secretary.

Kingsbridge Terminus, Dublin,
November, 1921. S 623

WREXHAM AND EAST DENBIGHSHIRE WATER CO.

12-IN. CAST IRON PIPES.

The Directors invite

Tenders for the Supply and

DELIVERY of about 800 tons of 12-in. CAST IRON PIPES and SPECIAL CASTINGS (to the British Standard Specification).

Particulars may be obtained on application to the undersigned. Sealed Tenders, endorsed "Tender for 12-in. Cast Iron Pipes," to be delivered at the Offices of the Company, Egerton Street, Wrexham, not later than 1st December next.

The Company do not bind themselves to accept the lowest or any Tender.

FREDERICK STORR,
Engineer and Secretary.

Water Offices,
Egerton Street, Wrexham.
8th November, 1921. S 552

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 7th December:—

Tenders for the Supply

of:—

1. AXLEBOXES for Wagons.
2. STEEL FISHBOLTS, NUTS AND WASHERS.
3. STEEL DOG SPIKES.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W. 1.
14th November, 1921. S629

BELFAST HARBOUR.

The Belfast Harbour Commissioners are prepared to receive

Tenders for the Construction

of a JETTY and DOLPHINS, on the Eastward side of the new Oil Berth, Musgrave Channel, Co. Down, all in accordance with Drawings which may be seen at the Office of the Harbour Engineer, Mr. T. S. Gilbert, M.Inst.C.E., from whom copies of the conditions of Contract, Specification, and form of Tender may be obtained.

Tenders must be made on the form provided for the purpose, and must be enclosed in a sealed envelope endorsed, "Tender for Jetty and Dolphins," and addressed to the undersigned, and delivered not later than Monday, the 19th December, 1921.

The Commissioners are also prepared to receive alternative offers for the above work in re-inforced concrete.

The Commissioners do not bind themselves to accept the lowest or any tender.

D. J. OWEN,
General Manager and Secretary.

Harbour Office, Belfast.
11th November, 1921. S 606

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

TENDER for the LAYING of 18 in. and 24 in. STEEL PIPES, Somerford to Bloxwich.

The South Staffordshire Waterworks Company invite

Tenders for the Laying and

JOINTING of about 16,000 lineal yards of STEEL WATER MAIN, 18 in. and 24 in. in diameter, from their intended Pumping Station at Somerford in the Parish of Brewood to Bloxwich, both in the County of Stafford, together with contingent works.

Forms of Tender, Specification, Bill of Quantities and Schedule may be obtained from, and Drawings inspected at the Offices of the Engineer-in-Chief, on and after November 21st, 1921, between the hours of 10 a.m. and 4 p.m. daily, Saturday excepted, upon the deposit of a cheque value Five Guineas, which will be returned on receipt of a bona-fide Tender, together with the return of all documents supplied.

Sealed Tenders, endorsed "Tender for Somerford—Bloxwich Main," must be delivered to the undersigned not later than Ten a.m. on Monday, December 12th, 1921. The Company do not bind themselves to accept the lowest or any Tender.

FRED J. DIXON, M.Inst.C.E.
Engineer-in-Chief.

30a, Paradise Street,
Birmingham.
November, 1921. S 619

COUNTY BOROUGH OF SOUTHEND-ON-SEA.

LEIGH WEST SEWERAGE.

CAST-IRON PIPES AND SPECIALS.

The Corporation of Southend-on-Sea invite

Tenders for the Supply of

about 145 Tons of CAST-IRON PIPES and SPECIAL PIPES.

General Conditions, Specification, Schedule and Form of Tender together with detail sketches, may be obtained upon application to Mr. Robt. H. Dyer, Borough Engineer, Municipal Buildings, Southend-on-Sea, upon payment of a deposit of £3 (Two Pounds), on or after Saturday, 19th November, 1921. The deposit will be returned on receipt of a bona-fide tender upon the form supplied together with return of all documents supplied.

Tenders in sealed Envelopes endorsed "Cast-iron Pipes, Leigh West Sewerage" to be delivered at my office on or before Twelve noon, Monday, 5th December, 1921.

No Tender will be considered unless made upon the prescribed Form.

The Corporation do not bind themselves to accept the lowest or any Tender.

The Contractor's attention is called to the fact that time for completion of delivery is an important factor.

By Order,
H. J. WORWOOD,
Town Clerk.

Town Clerk's Office,
Southend-on-Sea.
November, 1921. S 631

APPOINTMENTS OPEN.

RESEARCH DEPARTMENT.

ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF BALLISTICAL RESEARCH.

ASSISTANT II.

Required, One Assistant

II. Must be an Engineer with Honours Degree in Engineering or Mechanical Sciences.

Initial Salary £250 and bonus. (Total emoluments at present approximately £456).

The above post carries superannuation under a scheme similar to that of the Federated Universities.

Annual leave, six weeks.

Applications in writing, with copies of testimonials and references to any published work, should be made to the

CHIEF SUPERINTENDENT,
Research Department,
Royal Arsenal,
Woolwich,

from whom the conditions of Employment may be obtained. S 538

ROYAL AIR FORCE.

CIVILIAN EDUCATIONAL STAFF.

Required in January,

1922, in connection with the next entry of Boy Mechanics, several ASSISTANT MASTERS for the Schools of Technical Training (Boys)—Halton, near Wendover, Buckinghamshire, and Cranwell, near Sleaford, Lincolnshire.

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Basic Scale	£150—10—200—15—£350	
Bonus for cost-of-living index figure	minimum	153 17 6
	maximum	251 7 6
Total	minimum	303 17 6
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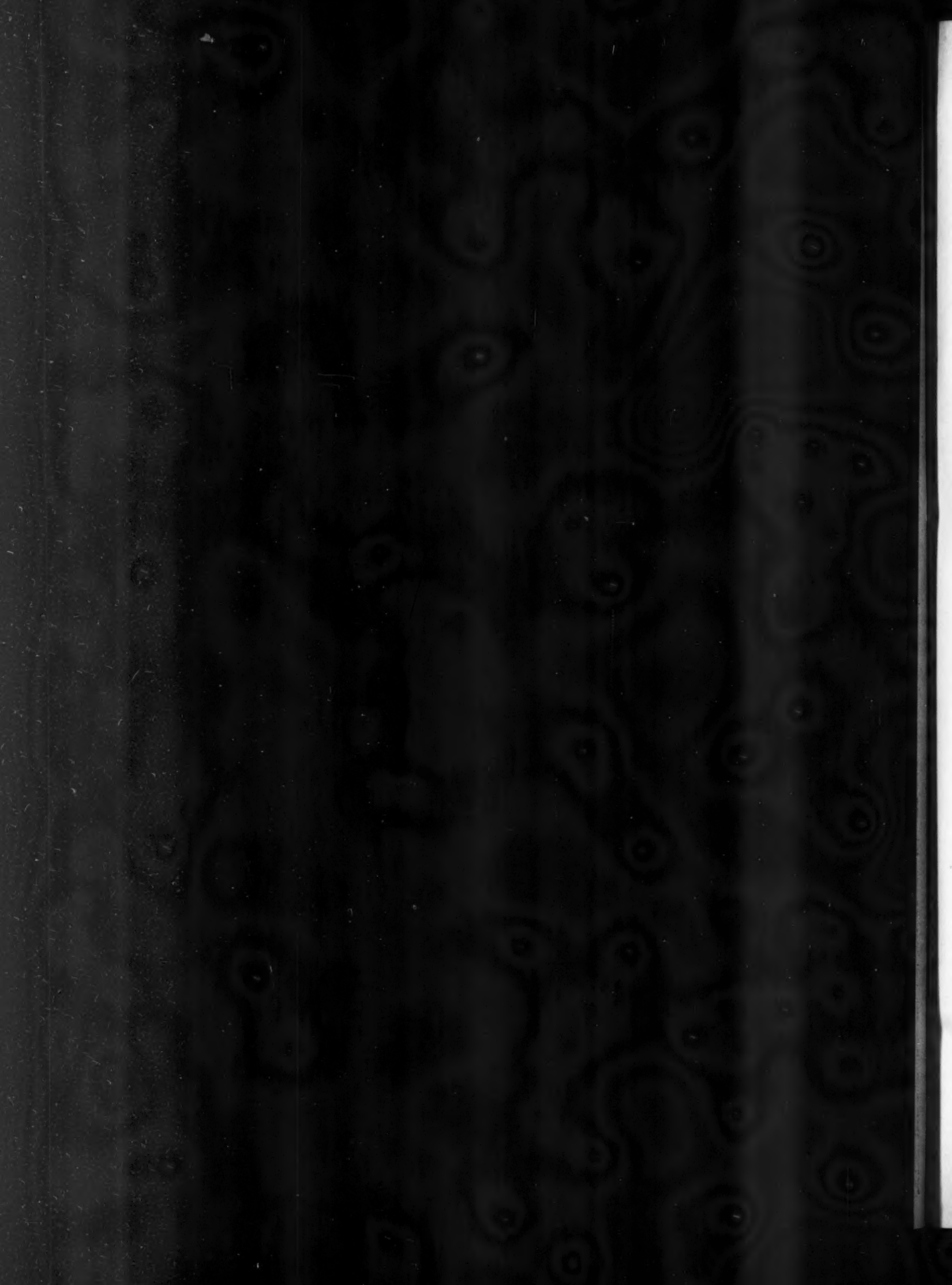
GRAHAM BALFOUR, Director of Education.
County Education Offices, Stafford, November, 1921.



THE GENERAL ORGANISATION OF INDUSTRY; PRESENT DAY TENDENCIES.

By Alex. Ramsay.

The organisation of industry in general is undergoing changes, not perhaps spectacular, but certainly important, changes which in their effect and significance, give food for much interesting speculation. Each Industrial decade has had its own marked characteristics, but the general trend has been towards a higher development of organisation in method and personnel. As a result the fierce individualism of the later Victorian era is rapidly disappearing and is being replaced by association and combination on the part of both Capital and Labour.

During the war, an interesting development was seen in the unusually big number of Amalgamations of Companies. It is true that some of them have since passed through troubled waters, and doubt has been expressed as to the wisdom of such grouping. There can be little doubt, however, that from the view of economy theory and practice, the step is a right one, and the probability is that a further extension of the principle will take place. The difficulties experienced have been common to all manufacturers, and have arisen through external conditions, which in point of fact, the larger Companies, through their more extensive trade ramifications and stronger financial interests, have been better able to withstand. The fact that the Finance of Industry is being gathered together and controlled by fewer hands will result in the power of the leaders of industry being enormously increased, and this power properly utilised, will do something to secure the economic good of the country against political factions who are sometimes tempted, in despite of their better judgment, to yield to clamour and expediency.

Employers, too, have taken other definite steps in an attempt to identify their interests with one another, and to find some common basis of action. A new body, the Federation of British Industries, came into being, and as a result some 20,000 companies, large and small, but representing in the aggregate a very large proportion of the country's manufacturing and commercial interests, are now able to express a common opinion upon the various matters which concern them. In the development of research and in the encouragement of science and art their influence has been felt. In the collection of information concerning the markets of the world, they have taken a useful part. The large number of meetings they have had with members of the Government on business issues give ground for belief that their influence on legislation has not been without effect. The employers of the country have never before spoken with so clear a voice or with such unanimity, and as a consequence their potential effectiveness is greatly enhanced.

There has been organised, too, the Confederation of British Employers Organisations, a body whose primary function is to survey and try to co-relate the labour conditions of the world, but more particularly to co-ordinate the actual working conditions of this country, in order to ensure that so far as possible no one section of industry shall act prejudicially to others. The need of this has long been apparent. The range of this country's industrial activities is enormous. While it is true that employers have been organised sectionally, it has been customary for them to give consideration only to the working conditions of their own particular branch of industry, with the result that considerable differentiation has arisen, which in its ultimate effect, is good for neither workpeople or employers.

In this connection numerous instances could be given, but one important example may suffice. It does not appear on the face of it that the manufacture of marine engines or electrical machinery has any real affinity with the small builder who employs 50 to 60 men on the erection of houses. And yet what is the fact? Over a considerable period the conditions in the building trade have been the bugbear of general industry. They have caused an unwarrantable drain on the financial resources of the country and stirred up much bitterness amongst workers in other industries where, perforce, regard had to be paid to economic values. Owing to lack of organisation, lack of resisting power, and small sense of community of interest between the Master Builders, the bricklayers and their helpers were able to attain conditions of employment greatly in advance of those enjoyed by many other classes of workers. In very many instances, bricklayers' labourers received higher wages than skilled mechanics. The result was inevitable. Building trade conditions became the weapon of offence used by all other Unions, and without any doubt affected adversely the general economic position of the country. The fact was never appreciated that builders were being maintained by the ill-spared money of the tax-payers, and no Union was ever found to express the view that even workpeople were not entitled to exploit the public need. The only desire appeared to be to strengthen privilege and to seek to extend it to sections of competitive industry, in which it was impossible to grant conditions which had no justification from the economic point of view.

The case for combination appears to be unanswerable. Doubtless, the British employer is by instinct an individualist, and only important reasons could persuade him to take any other course than to run his own business in his own fashion, and without too much regard to the need of circumstance of his neighbour. But the development in Trade Union activity has driven him more and more towards co-operation as a measure of self-defence, and it is clear that the class consciousness of labour which is now so marked, must have some reflex in the employers' attitude, if a reasonable stability is to be maintained in our economic life.

In view of the grouping of trade unions and the co-ordination of labour sought by central bodies it is significant to find, as an instance, that in a single industrial centre there are not less than twenty different employers' associations all connected with engineering and its allied trades, each negotiating separately with labour and determining working conditions without reference to the others.

It cannot be supposed that the operations of these individual sections have no influence on the general result, because it is by individual action that atmosphere is created; and if employing bodies are not large and strong enough to handle effectively the labour side of their economic interests, the inevitable result must be a general weakening of the whole position. It is not suggested that it may be possible to mould all employers' organisations into an entity, single thinking, and single acting, but undoubtedly the time has come when a very active movement should be made towards consolidation, with a view to joint action on general policy.

From the point of view of the community the issue is an all important one. The time is coming, and may not be very far distant, when those who at present direct industry, may be called upon, not as individuals, not even as trade sections, but as an employing class, to consider what can be done to hold in check the formidable and disintegrating forces—industrial and political—which are attacking their position from day to day.

It is doubtful whether the average employer realises the potential power of the forces working against him. No one can have failed to notice, for example, the striking importance of the interference of the House of Commons in the settlement of industrial disputes. It is extremely undesirable that it should seek to do other than act as a final court of appeal, but given a stoppage of sufficient seriousness for a sufficiently long time, and Parliament, as the keeper of the peace and the custodian of public interest, must inevitably intervene. Not only so, but as a rallying point of public opinion it is at all times an influence which cannot be ignored. Consider this circumstance in conjunction with the fact that the workers, with their class consciousness fully developed, are the masters of the ballot box, and a writing appears which it would be folly to disregard. It cannot yet be said that the development of working-class ambition is in the direction of a better understanding with Capital. On the contrary, the issue is already joined, and the future will lead to a trial of strength between the present controllers of industry on the one hand, and the advocates of nationalisation on the other. The battle will be fought over the staple industries by which we live, and if wise measures be not taken, the war losses may include the prosperity of the country. Community of interest is best safeguarded by common action: and any course that will strengthen the stable forces of the country, and safeguard economic prosperity, must be for the country's good.

And what of the labour side of the picture? An examination of the official report of a trade union congress gives probably the most comprehensive idea of the nature and extent of the trade union movement in its relation to industrial affairs. The list of bodies affiliated is a formidable one, but even more impressive is the comprehensive range of activities and the extraordinarily complete provision made for organising workpeople in the various branches of industry.

While, however, the number of unions runs into hundreds, the real power of the movement is in the hands of the larger groups, numbering about half a dozen. The miners, railwaymen, cotton operatives, engineers, dockers and semi-skilled unions, are so strong numerically, and embrace so many of those, who, by virtue of their capacity, are the leaders of the movement, that they inevitably dominate the national industrial policy of the workers, and inspire their political activities.

In these larger groups a very extensive measure of co-ordination already prevails. The unity of the miners is, of course, complete. The recent prolonged stoppage in the coal industry, while raising serious doubt as to the wisdom of the leadership, and the reasonableness of the rank and file, at least demonstrated beyond doubt that the miners in the various coal producing areas of the country are willing, even to the extent of sacrifice, to identify their interests with each other, and to exact obedience to the mandates of the executive.

The organisation of the railwaymen is very complete. While it is true that many employees are not members of the union, the number is too small to affect seriously any concerted action the National Union of Railwaymen might see fit to take. Although the enginemen and firemen belong to a separate organisation, the student of trade unionism would probably conclude that the only real cause of this continued separation is to be found in personal antagonisms, and that the time is bound to come when the whole of the railway workers will be members of one body, and under one leadership. Even at present it is very unlikely that one section would do anything to minimise the effect of strike action taken by the other.

The dockers have been associated with the two aforementioned unions in what has been known as the Triple Alliance. The potentialities of this alliance have, in the past, been greatly feared, and their attitude in one period of the recent coal strike gave rise to very considerable misgiving. As it happened, the miners decided on a line of conduct contrary to the advice of the other members of the Triple Alliance, and as a result an anticipated general strike of the members of the three bodies, failed to materialise. The country had been living in the shadow of the Triple Alliance for some years, and when it failed so signally at a time when united action appeared to be inevitable, opinion in certain quarters appeared to swing right round and take the view that industrial interests had nothing to fear from trade union amalgamations when these were strongly challenged. It would be wise, however, not to rely too much on such a contingency, or to condemn a principle because of failure in application. A triple, or even more extensive alliance, is not only possible, but within the range of imminent probability. The leaders of the trade union movement must be absolutely bankrupt of industrial statesmanship if they do not learn from the lessons of the past and create an organisation which does not permit one constituent member to have complete freedom of action without reference to the others. Had they acted together—a contingency of the most elementary character—had the strike of the Triple Alliance actually taken place, the country would not have been able to view the situation with the

comparative equanimity with which the coal stoppage alone was regarded. Elemental forces would have been brought into play and a page written in this country's history which might have affected the whole social structure. The shadow for the time being is lightened, but it will be an unforgiveable crime if advantage of the lull is taken only to prepare for further strife. The object of industrial statesmanship, on both sides, should now be to make an honest attempt to prevent these recurring crises, and to create a less suspicious atmosphere in which facts may be viewed in a true perspective.

The trade unions in developing their ideal of complete unity are faced with many interesting problems. There is an aristocracy of labour, and distinctions between the workers as sharply defined as those in other sections of society. To weld these grades into complete industrial unity demands a wide outlook, a delicacy of touch, and probably a spirit of sacrifice, not at present discernible in the trade union movement. Without elaborating the point, evidence of what is meant can be found in the strained and almost hostile relations of the semi-skilled and craft unions. The former unions embrace, and are recruited largely from the labouring class, and as this class is by far the most numerous in industry, the unions have a considerable responsibility in finding an outlet for their members' activities. In their view it is impossible that they should be confined to strictly labouring work, inasmuch as a great many of the operations in a modern factory can be quite easily undertaken by men who have received only a short period of training. In the interests of economic production their development is to be encouraged, because they provide a reservoir of labour, which is the most effective safeguard against a possibly dangerous monopoly, and because they provide the personnel for mechanical operations which would involve a serious waste, if undertaken by highly-trained labour.

The craft unions, on the other hand, are extremely jealous of their vested interest, and view with serious misgivings the encroachment of the non-apprenticed man. Much friction has already arisen on the question of demarcation, and when a trade revival is experienced it is not unlikely that this difficulty will become acute. The semi-skilled unions are in a strong position because key operations of production such as the generation of power and works transport, are largely in their hands and much as the craft unions dislike the situation they are not in a position to carry on without the assistance of the lesser skilled men.

Amongst trades unions the tendency to amalgamation has been quite notable. The engineers and several smaller bodies have joined together in the Amalgamated Engineering Union. The Amalgamated Union of Shipbuilding, Engineering and Constructional Workers, is a new organisation embracing several important societies. The Iron and Steel Trades Confederation provide another proof of the same practical movement towards consolidation. The proposal at present on foot to create a general staff for the trades union movement will doubtless, if effected, give a futher impetus in this direction, by drawing together the scattered elements, and unifying those bodies whose activities now overlap or are co-related.

The effect of a more complete organisation of capital and labour, in its relation to the maintenance of peace in industry, has still to be measured. The big battalions protect the community from much sporadic strife, because having greater interests at stake and a wide diversity of circumstance to consider, the leaders are impressed by their responsibility and steadied by a realisation of the far-reaching consequences of a dispute, although when conflict does arise, the consequences are naturally much more serious. It cannot be held, however, that a complete preparation for war is the best means of keeping the peace unless other conditions are interposed, and the discovery of these saving conditions is one of the most urgent and difficult problems industry has to face.

It is impossible to believe that the primitive and costly method of a fight *a outrance* can be regarded as the highest expression of the statesmanship of a well organised community. No doubt the method has its uses and its advocates, and the probability is that resort will again be made to it when fundamental principles—upon which compromise is impossible—are at stake. But those who can look far enough ahead and visualise the possible changes in the balance of economic and political forces, must feel that some responsibility is laid upon them of seeking to ensure that strife shall be made more difficult, and never other than the final and inevitable arbitrament.

What are the most moving circumstances the industrial negotiator has to face? The limitations placed upon him by economic forces and the suspicion and antagonism of the workpeople engendered by the influence of tradition! In a conference between employers and employed it is practically impossible to persuade the men that even-handed justice has been done, or to get them to take a dispassionate view of the merits of a case, firstly because they have an unshakable belief in the existence of "the nigger in the wood pile," secondly because they have, perhaps naturally, a complete bias to their own point of view, and thirdly because it is so difficult to reconcile the enthusiasm of ambition to the hard facts of reality.

For these reasons, therefore, settlements by direct negotiation, at present rest more upon a basis of force of inevitableness, than upon moral sanction, and until this position has been modified by a changed psychology, the peace of industry will remain upon a precarious foundation, liable to be disturbed at any time by sections who feel they can afford the luxury of a fight.

Much the same considerations apply to attempts at arbitration by outside bodies. It is probably too much too expect that any tribunal can command the unqualified confidence of both parties, not only as to its impartiality but as to its wisdom. Had a tribunal an undeniable authority, it could function in spite of this lack of faith, but it is clearly useless to seek to give such bodies mandatory powers for the obvious reason that powers of this nature can never, in fact, be exercised.

The mind of the country is speculating on the possible machinery for ensuring industrial peace just as the mind of the world is groping for the means of securing the international peace, but as in the latter so in the former; neither will come until there is such an earnest and determined will for peace that machinery will be recognised as a secondary consideration, and a means to an end, easily evolved.

What then remains? The cultivation of an atmosphere in which the truth will have a chance. Ill-will is more often caused by ignorance than justified by fact, and those who realise least our dependence on the stability of industry, are they who attack it most violently, and seek to bring to bear upon it the shattering influence of strife. If those primarily concerned in maintaining a healthy public opinion were willing to take a little personal trouble, there are a thousand and one ways of directing the public mind to realities, and the public mind moving in a definite direction is a force of incalculable power. Educate! Propagate! Do it deliberately when passions are cold, in an atmosphere of peace rather than when, as heretofore, the country is in the throes of an industrial crisis and faced with the imminence of social upheaval.

Experience in many a difficult situation has shown that the British people possess a moral sense that saves them from disaster. To this sense a wide-spread appeal should be made, and the result would be a larger tolerance and a greater energy which in themselves alone would do much to resolve our industrial difficulties. A machine will not function unless its parts synchronise. If Capital and Labour had an honest desire to co-operate for their mutual good, the machinery necessary to express their intention would be easily found. It would seem wise, therefore, to emphasise the fundamental considerations and take steps to influence them.

HARBOUR CONSTRUCTION IN FINLAND.—The extension of the harbour of Kotka, Finland, was commenced in the year 1911, assisted both by State grant and loan. There is a main pier, 281 m. long, 60 m. broad, and a depth of 7 m. The aggregate pier length of the harbour is now 700 m., but in addition there are five quays for local steamer traffic, of which four are new.

THE GAUGING OF PENETRATION IN PILE-DRIVING.

By ERNEST LATHAM, M.Inst.C.E.

THE driving of piles in many cases forms one of the principal features of construction in marine works. In order to obtain the necessary data as regards foundations in the sea or river bed it is usual, in cases where there is any doubt, to have borings taken or test piles driven, or to observe both precautions. The writer places greater reliance on the results of test piles than on the results of borings in so far as actual ability of the ground to carry loads is concerned.

If borings are decided on, it is usually wise to have them carried out by one of the several firms who specialise in this class of work; their plant is largely standardised, and they are better able to deal with the commoner delays which are likely to occur, due to broken boring tools or difficulties in driving or drawing the lining of the bore. As regards cost this is entirely a matter depending on the nature of the strata to be penetrated, and the conditions to be met with on the site. Test borings of this class must be distinguished from boring artesian wells, which for many reasons is obviously a more elaborate proceeding, and these latter wells are, of course, usually carried to much greater depths.

In driving test piles, very careful observation of the driving is necessary, as in driving from a "springy" stage or from floating craft, owing to the movement of the stage or the oscillation of the barge or pontoon, it is difficult to measure the actual penetration per blow which it is essential to observe closely when driving test piles from the moment when they begin to "pull up."

In driving permanent piles it is unfortunately necessary for practical reasons to average the penetration over a number of blows; this is common practice, but there are technical objections to it as if a pile has pulled up hard, this may obviously, have occurred on the first one or two of a series of blows and the balance of the series (before driving is stopped for the purpose of observation) may result in the destruction of the pile head or in certain cases, especially in reinforced concrete piles, even in the destruction of the pile itself.

The data of which it is necessary to record in test pile driving is best shown by a record of actual driving which is given below for a single test pile driven through clay and peat with an ultimate "set" in Thames ballast.

Record of Test Pile (Oregon Pine, 14 In. by 14 In.). Greenhithe, January 17, 1921.

No. of Blows.	Penetration.	No. of Blows.	Penetration.	No. of Blows.	Penetration.
	ft. in.		in.		in.
10	8 5½	10	1⅜	5	⅜
10	4 9½	10	1⅛	5	¼
10	4 0½	10	1⅛	5	7/32
10	3 4½	10	1⅛	5	⅜
10	2 6½	10	1⅛	5	7/32
10	2 0½	5	⅜	5	⅛
10	1 9	5	⅜	5	⅛
10	5½	5	⅜	5	⅛
10	3½	5	⅛	5	¼
10	3⅜	5	1	5	7/32
10	3	5	⅜	5	7/32
10	2½	5	⅜	5	⅜
10	2	5	⅛	5	⅛
10	2	5	⅜	5	⅛
10	2	5	⅜	5	5/32
10	2	5	⅜	5	5/32
10	1⅞	5	⅜	5	5/32
10	1⅞	5	⅜	1	5/32
10	1⅞	5	1		

Length overall	... ...	53 ft. 6 in.
Level of pile head	...	+ 16·49 O.D.
Level of shoe	... ...	− 37·01 O.D.
Penetration	... ...	42 ft. 6 in.
Level of ground	... ...	+ 5·50 O.D.
Final set (as above)	...	5/32 in.

The question of accurately determining the "set" for safe loads which permanent piles may be expected to carry has occupied the writer's attention for several years, mainly with the object of avoiding the technical objections of averaging the final set over a number of blows and the delay in stopping driving for the purpose of observation. As the result of experience in actual driving he prepared an empirical formula in 1914,* and to this future

* See "Maintenance of Foreshores," published by Messrs. Crosby, Lockwood, page 80.

contracts under his firm's jurisdiction have been satisfactorily carried out without failure in any case. This formula is dependent on a factor p, as given below :—

Final "Set" of Pile per Blow.	Value of Factor p.	
	Driving without Dolly.	Driving with Dolly.
Less than $\frac{1}{4}$ in.	0·20	0·15
Less than $\frac{1}{8}$ in.	0·15	0·12
Less than $\frac{1}{4}$ in.	0·12	0·08
Less than $\frac{1}{8}$ in.	0·10	0·05
Less than $\frac{1}{2}$ in.	0·09	0·03

The safe load is calculated as follows :—

$$B = \frac{L}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

L = safe load in tons.
p = factor as above.
B = driving force of blow in tons calculated as follows :—

$$B \times X = F \times T \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where X = penetration per blow in feet at or towards conclusion of driving.

F = fall of monkey in feet.
T = weight of monkey in tons.

Fig. 1. SECTION OF PILE.

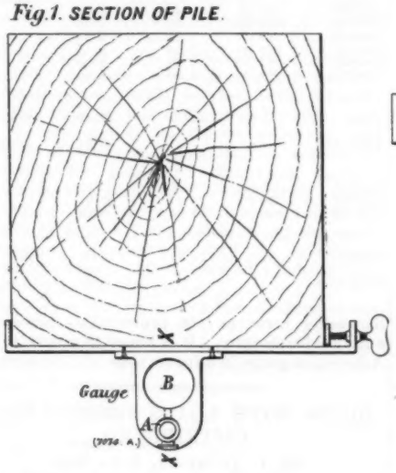


Fig. 2.

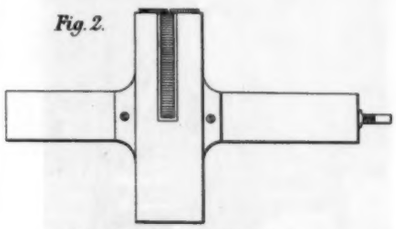


Fig. 3. SECTION THRO' X X

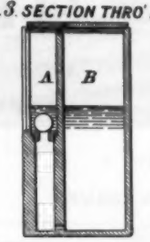
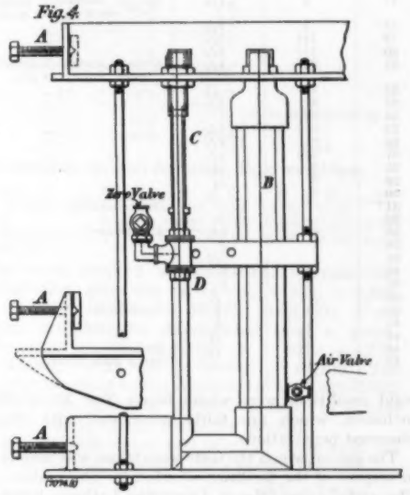


Fig. 4.



The British Steel Piling Company, who have a wide experience in pile driving, and no doubt working on similar lines, published in their handbook of 1921 a formula having a similar object.

Their formula is as follows :—

$$L = \frac{2\,w\,h}{S}\left(1 \times \frac{W}{w}\right) \quad . \quad . \quad (3)$$

Where L = safe load in pounds.
w = weight of monkey in pounds.
h = height of fall in feet.
S = penetration in inches per blow for the last few blows.
W = weight of pile in pounds.

In view of the fact that experience is the chief factor in specifying "set," one has to be very cautious in relying on any formulæ connecting "set" with safe loads. Except in exceptional cases, however, the first formulæ (equations 1 and 2) coupled with the correct value of the factor p may be taken as fairly reliable.

Another formula frequently adopted for lighter piles is the "Wellington" formula, as follows :—

$$L = \frac{2\,w\,h}{S + C} \quad . \quad . \quad (4)$$

C being a constant depending on the type of hammer used and frequency of the blows. This formula was recently applied by Mr. P. Allan, M.Inst.C.E., in piling for wharves at Newcastle Harbour, New South Wales.

As the formula quoted by the British Steel Piling Company was published at the time the writer was driving 70-ft. long timber piles in the Thames Estuary to a definite "set," he had the opportunity of applying both formulæ with the following results. The actual loads which these piles were called upon to carry was 80 tons each, and they were driven into Thames ballast with a final specified "set" of $\frac{1}{4}$ in. Applying the first formulæ (equations 1 and 2) the actual safe load worked out to 144 tons, and applying the second formula (equation 3) the actual safe load worked out to 153 tons. At first sight it appeared that the set originally specified had been more severe than was necessary, but it is as well to point out that, even where a factor of safety is already allowed for as in the above formulæ, a wide margin, where obtainable, should be adhered to, principally because so little of the theory of pile driving has yet been developed by civil engineers.

The Society of Engineers published a very useful paper by Mr. A. S. E. Ackermann, B.Sc., in 1919, entitled "Experiments with Clay in its Relation to Piles." The paper is of great value from the theoretical point of view, and it throws a good deal of light on previously little understood phenomena. It suffers, however, from the following defects :—

(*a*) The experiments are confined to those made with models.

(*b*) Loads were applied by continuous pressure and not by impact.

(*c*) The experiments were restricted to clay.

Briefly, in this and in a subsequent paper, Mr. Ackermann establishes the fact that at a critical pressure, varying with the nature and percentage moistness of the clay, the latter behaves physically as a liquid. This pressure he terms the "pressure of fluidity," and doubtless it explains the large amount of recoil shown by piles driven into London clay and similar foundations.

The formulæ quoted in this article must not be applied to quickly-operating single-acting steam or pneumatic hammers or to double-acting hammers of the McKiernan-Terry type. These types are of doubtful value in heavy pile driving such as is experienced in marine work and, in any event, more as yet has to be learnt about the "equivalent" performance of these hammers before anything in the nature of formulæ can be applied to them. In considering the question of permitting the use of such hammers for pile driving to form foundations for a large works under construction in 1919, where the permanent piles had to carry very heavy loads indeed, the writer came to the conclusion not to advise the use of these hammers unless the contractor was prepared to carry out an elaborate series of comparative tests between such hammers and the more common, though perhaps old-fashioned "clean-drop" falling weight type.

One of the principal difficulties experienced by resident engineers on public works is that of determining the actual set of the pile per blow without incurring the cost caused by the employment of a skilled observer and the delay referred to above of constantly stopping pile driving for the purposes of observation.

It is a curious fact that in such a common operation as pile driving so widely applied and utilised throughout the world, no serious attempt has apparently been made to design a suitable gauge for the purposes of making such measurements. This has probably been due to the obvious difficulties of subjecting a delicate instrument to the severe shock and jar of pile driving and to the difficulties of obtaining a suitable fixed point against which to measure the downward movement of the pile per blow under vibratory conditions.

The writer made one attempt to design such a gauge and to measure penetration by means of a single attachment to the pile, relying on the inertia of a liquid to record penetration. The original design evolved from this idea is shown in Figs. 1, 2 and 3, and consisted of a reservoir B communicating with an indicator column A, fitted with a ball valve. The intention was to fix the whole gauge rigidly to the pile as shown in Fig. 1. Under the impact of driving it was thought the body of the gauge would descend while the liquid contents would remain momentarily suspended, the liquid passing upwards in both chambers, but being trapped in chamber A—the amount of movement being read on the graduated scale shown in Fig. 2. The second chamber B was intended to act merely as a reservoir for supplying liquid to chamber A.

By the courtesy of the Empire Paper Mills, Limited, trials with such a gauge were made by Messrs. P. and W. Anderson, Limited, contractors, at Greenhithe, Kent, in February, 1921. These trials were conducted by Mr. Percy Neate, M.I.Mech.E., who re-designed the gauge so as to correct the obvious faults in the original design. In the experimental gauge a very sensitive disc valve replaced the ball valve shown in Fig. 3, and the supply chamber was fitted with a non-return air valve to enable both columns of water to be in exact balance before the delivery of the blow from the pile-driving hammer. This gauge is illustrated in Fig. 4, in which AA represent the clamps, and B the reservoir chamber as before. In this case, however, the "trapping" chamber is merely a piece of steam pipe D with the sensitive non-return valve at its head and an ordinary gauge glass C for the purposes of observation. The principle of this gauge as actually made was identical with the first suggestion.

The trials were disappointing owing to the heavy weight and consequent high relative inertia of the gauge fittings weighing in all 59 lb. The action of the gauge, however, was definite and well marked, the actual readings beings inconsistent owing to movement which took place between the gauge and pile head which movement would not have occurred had a lighter gauge been used with a more satisfactory attachment to the pile. The gauge was found to work with or without an air balance and presents possibilities of development. The view Fig. 5, page 686, shows this experimental gauge under test. The penetration of the pile was observed from adjacent firm ground by means of a dumpy

level and the actual test sheet obtained is given in the subjoined Table.

The recording chamber consisted of a gauge glass in the case of this experimental gauge. The inconsistency of the figures is apparent. The gauge, however, was designed to magnify the record by 5 to 4 by constricting the internal diameter of the recording chamber. Unfortunately, continual movement was observed between gauge and pile, and the only observations taken under anything like

Test on Inertia Gauge. New Jetty Contract. Empire Paper Mills, Limited, Greenhithe.

No. of Blow.	Penetration Recorded by Gauge.	Penetration Recorded by Actual Observation.	Remarks.
	in.	in.	
1	1 1/4	1 5/16	Air balance.
2	1 1/4	1 5/16	"
3	1 1/4	1	"
4	1 1/16	1 1/16	"
5	2	1/16	"
6	1 1/4	1	"
7	2	1/16	"
8	1/8	1/8	Gauge slack on pile head.
9	1 7/8	1/16	" "
10	1/8	1/16	" "
11	1/8	1/8	" "
12	1/16	1/16	No air balance.
13	1/8	1/8	Gauge still slack on pile head.
14	1/8	1 1/4	" "
15	1/8	1 1/8	" "
16	1/8	1 7/8	" "
17	1/8	1 7/8	No air balance; gauge still slack on pile head.
18	1/8	1 7/8	" "
19	1 1/4	1 7/8	" "
20	1 1/8	1 7/8	" "
21	2 1/8	1 7/8	Attempt made to re-attach gauge rigidly to pile.
22	3	1 1/8	" "
23	3 1/16	1 7/8	" "
24	3 1/16	1	" "
25	2 1/8	1 7/8	" "
26	2 1/8	1 7/8	" "
27	2 1/8	1 7/8	" "
28	3 1/16	1 1/8	" "
29	3	1 1/8	" "
30	2	7/8	" "
31	—	—	Diagram taken.
32	—	—	"
33	1	1 1/16	Air balance.
34	1	1	"
35	1	1/16	"
36	1 1/8	1	"
37	1/8	1	"
38	1/16	1/16	"
39	1/16	1/8	Gauge loose.
40	1/8	1/8	"
41	1/8	1/16	"
42	1/8	1/8	Air leak.
43	1/8	1/16	Gauge glass broke.

rigid conditions were where blows Nos. 33 to 39 inclusive, which are fairly consistent with the observed penetrations.

The site on which the tests were taken was unique in respect of the facilities afforded for observation. The writer's firm (Messrs. Carey and Latham) being at the time responsible as consulting engineers for carrying out several contracts for the Empire Paper Mills, were desirous of ascertaining the nature of the ground behind an existing wharf with a view to extending its capacity landwards. These new works are shown in the plan Fig. 6, and the position of the test piles is shown also. Piles C and D afforded singularly good opportunities for observation, being driven practically right against a permanent and rigid existing structure from which accurate measurements of final sets per blow could be taken.

Attempts were made to obtain an autographic record of a blow in two cases (blows Nos. 31 and 32). This was done very simply by placing a smooth board across the face of the pile, rigidly resting it on the permanent works and passing a pencil slowly across its extremity, and against the pile during the blow. The first attempt failed owing to bad timing, but the second was curiously successful, and is reproduced in Fig. 7 to full scale. This diagram was taken by Mr. Neate and has been the subject of some speculation. It most emphatically shows that initial penetration in this case largely exceeded the final set. Mr. Neate's view is that the first upward sweep of the curve represents the actual dip or drop of the pile head under the blow, the vibratory periods near the crest movements caused by the bounce or rebound of the monkey and the final leg of the curve the recoil due to earth pressure exerted against the shoe of the pile by the violently-disturbed strata beneath it. This view is in all probability correct, but the curve may be of interest to all civil engineers and is worthy of discussion.

At the request of the council of the Institution of Civil Engineers the writer introduced the subject of inertia gauges in relation to pile-driving to the Engineering Conference of 1921, and the discussion which followed he considers to be of value, as also

Fig. 5.

Fig. 6.

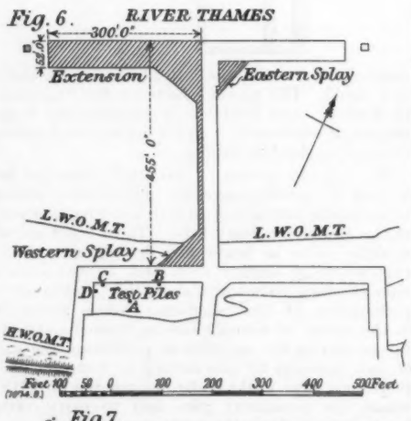
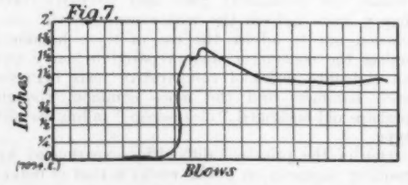


Fig. 7.



were two other inertia gauges exhibited at the Conference. These gauges were respectively exhibited by Mr. A. S. E. Ackermann, and by Mr. J. W. Fergusson. In both cases the idea of an inertia gauge to record pile sets had been obtained from the writer, but the gauges themselves were substantially different in design. The Ackermann gauge is based on utilising inertia but no liquid is employed. The gauge consists of a weight suspended by a helical spring. The top end of the spring is rigidly attached to the pile, and the weight hangs freely. Under impact the pile is driven downwards and the weight momentarily remains in its original position. The closure of the spring, therefore, is a direct measurement of the movement of the pile. Mr. Ackermann's gauge has been highly developed in many details. An autographic curve is obtained by a pencil attachment, and a horizontal movement is given to the recording chart. The net result is an autographic curve similar to that shown in Fig. 7. Mr. Ackermann has kindly supplied the present writer with a record of his experiments, and has given permission for the appended figures to be published. The results are given below, and the

Summary of Results obtained with the Ackermann gauge.

Date.	No. of Experiment.	Actual Set of Pile in C.M.S.	Set Recorded by the Autographic Curves in C.M.S.	Remarks.
1921.				
June 25 ..	267 (*b*)	2·45	2·45	
June 25 ..	267 (*c*)	2·70	2·55	Max. error — 5·6 per cent. too little.
June 25 ..	267 (*d*)	2·46	2·40	
June 25 ..	267 (*e*)	2·53	2·70	Trip gear failed.
June 25 ..	267 (*f*)	2·43	2·35	
June 26 ..	268 (*a*)	2·36	2·36	
June 26 ..	268 (*b*)	2·25	2·25	
June 26 ..	268 (*c*)	2·20	2·15	
June 28 ..	269 (*a*)	2·00	2·00	
June 28 ..	269 (*b*)	1·90	1·90	
Totals ..	—	20·75	20·41	Mean error — 1·64
Total error	—	—	— 0·34	per cent.
June 28 ..	270 (*a*)	3·80	3·60	
June 28 ..	270 (*b*)	4·00	3·65	
June 28 ..	270 (*c*)	4·00	3·80	
Totals ..	..	11·80	11·05	Mean error — 6·35
Total error	..		— 0·75	per cent.

increasing error as the penetration increases is a noticeable feature. It is hoped to revert to the Ackermann gauge in a future issue of ENGINEERING.

BEAMS WITH LOADS IRREGULARLY DISTRIBUTED.

By T. THOMPSON, B.A., B.Sc.

(*Concluded from page* 658.)

Smoothing Out the Load-Intensity Graph.—The following examples show how discontinuous load systems may be reduced to their approximately equivalent sine series. Since, however, "smoothing-out" processes introduce an incalculable human element, it is safer in the simpler cases of loading to find the bending moments by the usual methods and to express the bending moment, not the load intensity, as a sine series. Thus from the series

$$M = A_1 \sin\frac{\pi x}{l} + A_2 \sin\frac{2\pi x}{l} + A_3 \sin\frac{3\pi x}{l} + \&c.$$

we can deduce the deflections in the form

$$z = \frac{l^2}{\pi^2 E I}\left(A_1 \sin\frac{\pi x}{l} + \frac{A_2}{2^2}\sin\frac{2\pi x}{l} + \frac{A_3}{3^2}\sin\frac{3\pi x}{l} + \&c.\right)$$

With loading which is at all complicated the calculations of end-reactions and of bending moments become very tedious. By the present method all such work may be avoided.

Example 5.—A beam of 10 ft. span carries loads of 200 lb./ft. from $x = 1$ ft. to $x = 3$ ft., and of 400 lb./ft. from $x = 3$ ft. to $x = 7$ ft. To find an equivalent sine series for this loading.

The actual loading is shown by the full line in Fig. 3. This is smoothed out into the dotted curve, shown on the same figure. The new ordinates at each sixth of the span are :

$$a_1 = 160,\ a_2 = 340,\ a_3 = 420,\ a_4 = 280,\ a_5 = 30,$$

from which we derive harmonic coefficients

$$w_1 = 351,\ w_2 = 55,\ w_3 = -77,\ w_4 = 20,\ w_5 = -7{\cdot}5.$$

These indicate a B.M. at mid-span

$$= \frac{100}{\pi^2}\left(351 + \frac{77}{9} - \frac{7{\cdot}5}{25}\right)$$

$$= 3640 \text{ lb.-ft.}$$

as compared with the exact value 3,600 lb./ft. In view of this close agreement of the B.M. values, we can rely upon the method to furnish the deflections also with considerable accuracy.

Example 6.—A beam of 22 ft. span carries concentrated loads of 4 tons at $x = 1$ ft., 4 tons at $x = 5{\cdot}7$ ft., 13 tons at $x = 11$ ft., and 5 tons at $x = 21$ ft. To find a sine series approximately equivalent to this loading.

On an arbitrary base, *i.e.*, assuming any value for the reaction at $x = 0$, set out a shearing force diagram, as shown by the full-line graph in Fig. 4. Estimate the gradients of this graph at each sixth of span, first smoothing out the abrupt steps if necessary. The gradients are the equivalent load intensities, being the changes in shearing force per foot of span. In Fig. 4 the mid-points of the steps serve as guide points, the gradient lines being drawn directly without any smoothing out. In the present case one gradient line serves for both a_1 and a_2, and another for both a_4 and a_5.

The load intensities (tons/ft.) thus obtained are

$$a_1 = a_2 = 1{\cdot}3,\ a_3 = 2{\cdot}2,\ a_4 = a_5 = 1{\cdot}0,$$

from which the sine series is derived as

$$w = 1{\cdot}78 \sin\frac{\pi x}{l} + 0{\cdot}17 \sin\frac{2\pi x}{l} + 0{\cdot}03 \sin\frac{3\pi x}{l} + 0{\cdot}45 \sin\frac{5\pi x}{l}$$

As a check upon this result, the B.M. at mid-span by the series is 88·2 tons/ft., comparing well with the exact value 87·4 tons/ft.

Cantilever Beams.—The harmonic method, though particularly applicable to beams simply supported at the ends, can be readily adapted to the cases of cantilever, built-in, and continuous beams.

In the case of the cantilever, owing to the simplicity of the end conditions, the numerical integrations for B.M. and deflections become straightforward operations; consequently, that method may be preferred to the harmonic method, especially if point-to-point values along the span are required. If, however, only the maximum B.M. or deflection is to be calculated, the harmonic method will be found superior.

Assume that the free end of the cantilever is at $x = 0$. The reaction R_0 at $x = 0$ for the same beam simply supported is equal to the shearing force F at $x = 0$. Hence, substituting in equation (ii), page 656 *ante*.

$$R_0 = \frac{l}{\pi} \cdot \left(w_1 + \frac{w_2}{2} + \frac{w_3}{3} + \frac{w_4}{4} + \frac{w_5}{5} \right).$$

Similarly the reaction at $x = l$ is

$$R_l = \frac{l}{\pi} \cdot \left(w_1 - \frac{w_2}{2} + \frac{w_3}{3} - \frac{w_4}{4} + \frac{w_5}{5} \right).$$

The maximum B.M. therefore = moment about fixed end of cantilever, of the applied load, = moment of reaction R_0 about fixed end = $R_0 l$. In general, B.M. for cantilever at section x = (B.M. for simple beam) − $R_0 . x$.

The formulæ for the deflections will be more readily understood by assuming that equal and opposite forces R_0 are applied at $x = 0$. These forces, of course, neutralise each other, so that the beam is undisturbed by them. The deflection at $x = 0$ due to the downward force R_0 is $\frac{R_0 l^3}{3 E I}$. That due to the upward force R_0 combined with the actual loading is the deflection of the simple beam measured from the tangent at $x = l$, *i.e.*, $i_l \times l$, where

$$i_l = \frac{l^3}{\pi^3 E I} \cdot \left(w_1 - \frac{w_2}{2^3} + \frac{w_3}{3^3} - \frac{w_4}{4^3} + \frac{w_5}{5^3} \right)$$

by equation (iv). The difference of these two terms gives the deflection at the free end. The deflections at each sixth of span measured from the free end, due to the downward end load R_0, are equal to $\frac{R_0 l^3}{1296 E I}$ multiplied by the coefficients in the following table :—

x/l	0	1/6	2/6	3/6	4/6	5/6	6/6
Coefficient	432	325	224	135	64	17	0

Once the value for $x = 0$ has been calculated, the other values can, by means of this table, be read off from a slide rule. The remaining load causes further deflections equal to those for the simple beam, diminished by $i_l (l - x)$ since the deflections are now measured from the tangent at the fixed end. These relations are illustrated in Fig. 5, page 688.

Example 7.—A cantilever 30 ft. long, No. 25 B.S.B. section, I = 428, Z = 57·06, E = 30 million lb. per square inch, carries a load distributed as follows :—

x ft.	0	5	10	15	20	25	30
w lb./ft.	50	100	140	160	160	130	60

The end $x = 0$ is free. To find the B.M. and the deflections.

The scheme for the harmonic load intensity coefficients is (see page 656 *ante*) :—

100	140	160
130	160	160
230	300	320
−30	−20	
550	− 52	460
520	− 35	320
1070	− 87	
30	− 17	140

Fig. 3.

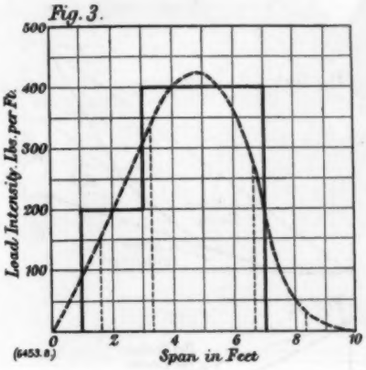
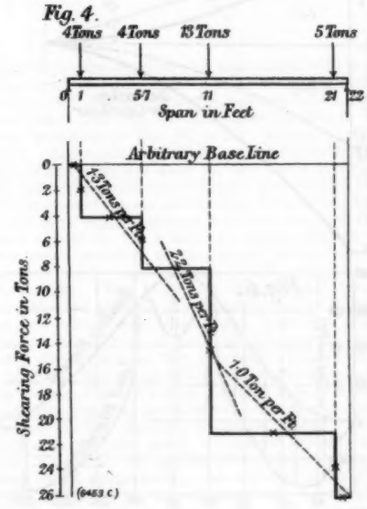


Fig. 4.



We thus obtain

$$w = 178{\cdot}3 \sin\frac{\pi x}{l} - 14{\cdot}5 \sin\frac{2\pi x}{l} + 23{\cdot}3 \sin\frac{3\pi x}{l} - 2{\cdot}8 \sin\frac{4\pi x}{l} + 5{\cdot}0 \sin\frac{5\pi x}{l},$$

and therefore

$$R_0 = \frac{l}{\pi}\left(178{\cdot}3 - \frac{14{\cdot}5}{2} + \frac{23{\cdot}3}{3} - \frac{2{\cdot}8}{4} + \frac{5{\cdot}0}{5}\right),$$

$$= (178{\cdot}3 - 7{\cdot}25 + 7{\cdot}77 - 0{\cdot}70 - 1{\cdot}0) \times \frac{l}{\pi},$$

$$= 179{\cdot}1\ \frac{l}{\pi} = 1710 \text{ lb.}$$

The maximum B.M. $= R_0 l = 51{,}300$ lb.-ft., to which should be added, on account of neglected end load, the moments about the fixed end of $\frac{1}{3} \times 50 \times 5$ lb. at $x = \frac{5}{4}$ ft. and of $\frac{1}{3} \times 60 \times 5$ lb. at $x = \left(30 - \frac{5}{4}\right)$ ft., *i.e.*, $\frac{1}{3} \times 50 \times 5 \times \frac{115}{4} + \frac{1}{3} \times 60 \times 5 \times \frac{15}{4}$, or 2,520 lb.-ft. (minimum). These corrections increase the maximum B.M. to about 54,000 lb.-ft., the corresponding stress being 5·08 tons per square inch.

The end deflection

$$= \frac{R_0 l^3}{3 E I} - i_l l,$$

where

$$i_l = \frac{l^3}{\pi^3 E I}\left(178{\cdot}3 + \frac{14{\cdot}5}{2^3} + \frac{23{\cdot}3}{3^3} + \frac{2{\cdot}8}{4^3} + \frac{5}{5^3}\right).$$

$$= 181 \frac{l^3}{\pi^3 E I} \text{ (if lengths are all in feet),}$$

$$= \frac{181}{12} \frac{l^3}{\pi^3 E I} \text{ (if lengths are all inches).}$$

so that

$$i_l l = \frac{181}{12} \frac{l^4}{\pi^3 E I} = \frac{181 \times (360)^4}{12 \times \pi^3 \times 30{,}000{,}000 \times 428} = 0{\cdot}635 \text{ in.}$$

Also

$$\frac{R_0 l^3}{3 E I} = \frac{R_0 l \times l^2}{3 E I} = \frac{(54{,}000 \times 12) \times (360)^2}{3 \times 30{,}000{,}000 \times 428} \text{ (all inch units)}$$

$$= 2{\cdot}180 \text{ in.}$$

The end deflection is therefore 2·180 − 0·635 = 1·545 in.

To find the values of the B.M. at each sixth of span, we first calculate them as for a simple beam and then deduct $R_0 x$.

$$M = \frac{l^2}{\pi^2}\left(178{\cdot}3 \sin\frac{\pi x}{l} - \frac{14{\cdot}5}{2^2} \cdot \sin\frac{2\pi x}{l} + \frac{23{\cdot}3}{3^2} \cdot \sin\frac{3\pi x}{l} - \frac{2{\cdot}8}{4^2} \cdot \sin\frac{4\pi x}{l} + \frac{5{\cdot}0}{5^2} \cdot \sin\frac{5\pi x}{l}\right) - R_0 x.$$

The B.M. values for the simple beam are given by the scheme (see page 657 *ante*) :—

178·3	−3·6	2·6	
0·2	−0·2	2·6	
178·5	−3·8	5·2	
178·1	−3·4		
183·7	304·1	357·0	
−6·6	−5·9	5·2	
177·1	298·2		to be multiplied by $\frac{l^2}{2\pi^2}$
190·3	310·0	351·8	

Multiplying out and deducting $R_0 x$, we obtain

x (ft.)	0	5	10	15	20	25	30
M for beam ...	0	8,100	13,600	16,000	14,100	8,700	0
$R_0 x$	0	9,000	18,000	27,000	36,000	45,000	54,000
M for cantilever (lb.-ft.)	0	−900	−4,400	−11,000	−21,900	−36,300	−54,000

The usual method of calculation, by numerical integration, gives the values: 0, − 940, − 4,310, − 11,060, − 21,690, − 36,125, − 53,560. If six other ordinates be interpolated from a graph, numerical integration gives: 0, − 872, − 4,216, − 10,991, − 21,716, − 36,356, − 54,109. The two latter sets of values are stated to more significant figures than the data warrant, in order to exhibit the reliability of the harmonic method.

For the deflections, first calculate these as in the case of the simple beam. By equation (v), *ante*

$$z = \frac{l^4}{12 \pi^4 E I}\left(178{\cdot}3 \sin\frac{\pi x}{l} - \frac{14{\cdot}5}{2^4} \sin\frac{2\pi x}{l} + \frac{23{\cdot}3}{3^4} \sin\frac{3\pi x}{l} - \&c.\right)$$

$$= \frac{l^4}{12 \pi^4 E I}\left(178{\cdot}3 \sin\frac{\pi x}{l} - 0{\cdot}9 \sin\frac{2\pi x}{l} + 0{\cdot}3 \sin\frac{3\pi x}{l}\right),$$

subsequent terms being negligible. (We divide by the 12 to convert the pounds per foot into pounds per inch, so as to obtain z in inches, if l is in inches.)

178·3	−0·9	0·3	
0	0	0·3	
178·3	−0·9	0·6	
178·3	−0·9		
178·9	308·9	355·6	
−1·6	−1·6	0·6	
176·3	307·3		to be multiplied by $\frac{l^4}{24 \pi^4 E I}$
180·5	310·5	356·0	

The resulting products are entered in the table below in the line "z (beam)." The values of "z due to R_0" entered in the next line are obtained from the table of coefficients given in the explanatory paragraph preceding this example. The values in the remaining line "z due to $i_l (l - x)$" are obtained by taking proportional parts of $i_l l$, or 0·635. Due regard must be had to the signs of these three components.

The final values of the deflections can now be obtained :—

z (ft.)	0	5	10	15	20	25	30	
z (beam)	0	0·099	0·172	0·199	0·174	0·101	0	downwards
z due to R_0	2·180	1·640	1·131	0·682	0·324	0·086	0	downwards
z due to $i_l (l-x)$	0·635	0·530	0·424	0·318	0·212	0·106	0	upwards
z (cantilever)	1·545	1·209	0·879	0·563	0·286	0·081	0	downwards

The values obtained by numerical integration from

the seven given ordinates are : 1·540, 1·201, 0·867, 0·551, 0·275, 0·075, 0. If six more ordinates are interpolated, the values become :

1·546 1·212 0·878 0·561 0·283 0·080 0

Example 8.—The method of the preceding example may be used to calculate the bending moments on the ship structure due to the load system shown in Fig. 6. Although it would be possible to treat the whole structure as a simple beam, the conditions that both end reactions must be zero affording a check upon the harmonic load-coefficients, yet it will be evident that five ordinates only would be insufficient to represent accurately such wide variations in the loading. Since the load intensity is nearly symmetrical about the centre of the span, the maximum B.M. must also occur nearly at the centre. Each half of the structure may therefore be considered as a cantilever, so that the interval between ordinates may be halved.

The origin $x = 0$ being taken at the stern, the load intensities for the after half of the length are :—

x (ft.)	0	32½	65	97½	130	162½	195
w (tons-ft.)	0	16·0	18·0	11·3	−1·8	−32·5	−22·5

The working (page 657 *ante*) will appear as follows :—

16·0	18·0	11·3
−32·5	−1·8	11·3
−16·5	16·2	22·6
48·5	19·8	
6·10	84·03	−33·00
28·07	34·30	22·60
34·17	118·33	
−21·97	49·73	−55·60

Hence

$$w = \frac{1}{6}(34{\cdot}17\,s_1 + 118{\cdot}33\,s_2 - 55{\cdot}60\,s_3 + 49{\cdot}73\,s_4 - 21{\cdot}97\,s_5),$$

where

s_n represents "sin $\frac{n\pi x}{l}$," l being 195 ft.

Therefore

$$M = \frac{l^2}{6\pi^2}(34{\cdot}17\,s_1 + 29{\cdot}58\,s_2 - 6{\cdot}18\,s_3 + 3{\cdot}11\,s_4 - 0{\cdot}88\,s_5) - R_0 x,$$

where

$$R_0 = \frac{l}{6\pi}(34{\cdot}17 + 59{\cdot}16 - 18{\cdot}53 + 12{\cdot}43 - 4{\cdot}39) = \frac{l}{6\pi} \times 82{\cdot}84.$$

The value of M at the mid-ship section is found at once from

$$M\,(\text{mid-ship}) = -R_0 l = -\frac{l}{6\pi} \times 82{\cdot}84 \times 195 = -167{,}000 \text{ ton-ft.},$$

with a correction for mid-ship load

$$= \left(\frac{1}{3} \times \frac{l}{6} \times 22{\cdot}5\right) \times \left(\frac{1}{4} \times \frac{l}{6}\right)$$

= 2,000 ton-ft. minimum, or 4,000 ton-ft. maximum.

The corrected value of the B.M. at mid-ship is therefore

$$-164{,}000 \pm 1{,}000 \text{ ton-ft.}$$

This value is slightly greater (numerically) than that given by the graph of bending moments shown in Fig. 6, obtained by doubly integrating the load curve with a planimeter. As this latter method involves the "fairing" of the shearing force curve through a limited number of points, themselves subject to slight errors, it certainly cannot be deemed more reliable than that exemplified above.

Overhanging, Built-in, and Continuous Beams.—The bending moment diagrams for these types of loading are derived from that for the corresponding simply-supported beam, loaded within the span, by superposing on it the trapezoidal negative B.M. figure due to the moments applied at the supports.

If the ends overhang, the moments at the supports are found by treating the overhanging ends as cantilevers, as explained in Example 7.

For built-in beams, we use the well-known theorems :—

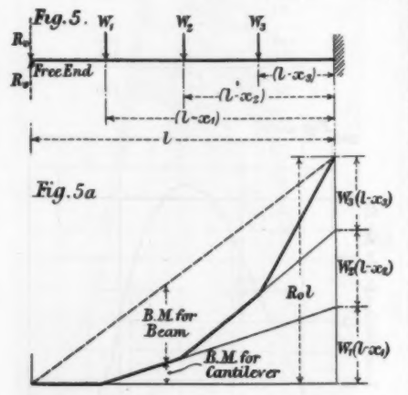
(Area of B.M. figure)/EI = angle (radians) between tangents to the bent beam at the supports . . (I)

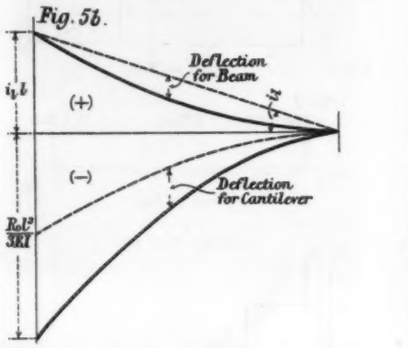
and

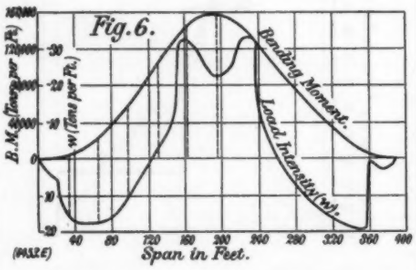
(Area of B.M. figure × distance of its centroid from a support)/EI = deflection of that support measured above the tangent at the other support . . . (II)

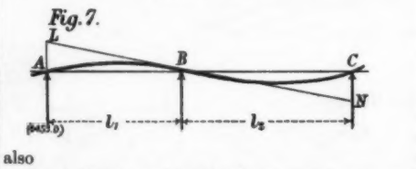
If it be assumed that the ends remain fixed in the same straight line, the right-hand members of both equations reduce to zero. And since

(area of B.M. figure for built-in beam) = 0
= (area of B.M. figure for simple beam)
− (area of B.M. figure due to negative end-moments),









therefore

(area of B.M. figure for simple beam)
= (area of B.M. figure due to end-moments) ;

Similarly, from equation (II) we deduce that the moments about a support for these areas (*i.e.*, area of B.M. figure × distance of its centroid from a support) are equal. If M_0 and M_l are the moments at the ends $x = 0$ and $x = l$ respectively, then

area of B.M. figure due to end moments $= -\frac{l}{2}(M_0 + M_l)$

= area of B.M. figure for simple beam $= \frac{2l^2}{\pi^2}\left(\frac{w_1}{1^3} + \frac{w_3}{3^3} + \frac{w_5}{5^3}\right)$;

also

moment about $x = 0$ of B.M. figure due to end moments

$$= -\frac{M_0 l}{2} \times \frac{l}{3} - \frac{M_l l}{2} \times \frac{2l}{3} = -\frac{(M_0 + 2M_l)l^2}{6}$$

= moment about $x = 0$ of B.M. figure for simple beam

$$= \frac{l^4}{\pi^3}\left(\frac{w_1}{1^3} - \frac{w_2}{2^3} + \frac{w_3}{3^3} - \frac{w_4}{4^3} + \frac{w_5}{5^3}\right)$$

Hence we deduce :

$$\frac{M_0 + M_l}{2} = -\frac{2l^2}{\pi^3}\left(\frac{w_1}{1^3} + \frac{w_3}{3^3} + \frac{w_5}{5^3}\right)$$

$$\frac{M_0 - M_l}{2} = -\frac{6l^2}{\pi^3}\left(\frac{w_2}{2^3} + \frac{w_4}{4^3}\right)$$

The separate values of M_0 and M_l may be obtained by adding and subtracting corresponding sides of this last pair of equations.

In the case of a continuous beam, the moments at the supports are related by "the theorem of three moments," which expresses the condition that the inclination of the beam is unaltered at a support.

Let A, B, C (Fig. 7) be three successive supports, the span A B being l_1 and the span B C being l_2. Denote the load coefficients for the span A B by unaccented letters w_1, w_2, w_3, &c., and those for the span B C by accented letters w_1', w_2', w_3', &c. If L B N, the tangent at B to the bent beam, intersects the verticals through A and C at L and N respectively, and if A, B, C, remain in line, then the triangles L A B and N C B are similar, so that L A/A B = N C/C B.

Since this equation is equivalent to

(deflection of A below tangent at B)/l_1
= (deflection of C above tangent at B)/l_2,

we have, by equation (II), assuming that E and I are the same for both spans,

(moment about A of complete B.M. figure for span AB)/l_1
= − (moment about C of complete B.M. figure for span BC)/l_2.

i.e.,

$$\frac{1}{l_1}\cdot\left\{\frac{(M_A + 2M_B)l_1^2}{6} + \frac{l_1^4}{\pi^3}\left(\frac{w_1}{1^3} - \frac{w_2}{2^3} + \frac{w_3}{3^3} - \frac{w_4}{4^3} + \frac{w_5}{5^3}\right)\right\}$$
$$= -\frac{1}{l_2}\left\{\frac{(M_C + 2M_B)l_2^2}{6} + \frac{l_2^4}{\pi^3}\left(\frac{w_1'}{1^3} + \frac{w_2'}{2^3} + \frac{w_3'}{3^3} + \frac{w_4'}{4^3} + \frac{w_5'}{5^3}\right)\right\},$$

$$\therefore\ M_A l_1 + 2M_B(l_1 + l_2) + M_C l_2 = -\frac{6}{\pi^3}\left\{l_1^3\left(\frac{w_1}{1^3} - \frac{w_2}{2^3} + \frac{w_3}{3^3} - \frac{w_4}{4^3} + \frac{w_5}{5^3}\right) + l_2^3\left(\frac{w_1'}{1^3} + \frac{w_2'}{2^3} + \frac{w_3'}{3^3} + \frac{w_4'}{4^3} + \frac{w_5'}{5^3}\right)\right\}.$$

The corresponding equations for the other intermediate supports, together with the two equations of condition for the end supports, suffice for the calculation of the B.M. at every support.

When unequal bending moments M_0 and M_l are applied at the points of support $x = 0$ and $x = l$, the reactions R_0 and R_l due to the intervening load are modified from their "simple beam" values by the transference of a force $(M_0 - M_l)/l$, reckoned positive upwards, from R_0 to R_l. If the support is at the junction of two spans, the reaction there will be the sum of those due to each span separately. Thus for an overhanging beam, if W_0 is the load which overhangs at the end $x = 0$ and W_l that at the end $x = l$, then

$$R_0 = W_0 + \frac{l}{\pi}\left(\frac{w_1}{1} + \frac{w_2}{2} + \frac{w_3}{3} + \frac{w_4}{4} + \frac{w_5}{5}\right) - \frac{M_0 - M_l}{l}$$

$$R_l = W_l + \frac{l}{\pi}\left(\frac{w_1}{1} - \frac{w_2}{2} + \frac{w_3}{3} - \frac{w_4}{4} + \frac{w_5}{5}\right) + \frac{M_0 - M_l}{l}$$

For a beam rigidly built-in :

$$R_0 = \frac{l}{\pi}\left\{\left(\frac{w_1}{1} + \frac{w_2}{2} + \frac{w_3}{3} + \frac{w_4}{4} + \frac{w_5}{5}\right) + \frac{12}{\pi^2}\left(\frac{w_2}{2^3} + \frac{w_4}{4^3}\right)\right\},$$

$$R_l = \frac{l}{\pi}\left\{\left(\frac{w_1}{1} - \frac{w_2}{2} + \frac{w_3}{3} - \frac{w_4}{4} + \frac{w_5}{5}\right) - \frac{12}{\pi^2}\left(\frac{w_2}{2^3} + \frac{w_4}{4^3}\right)\right\}.$$

For a continuous beam :

reaction at support B = reaction R_l for span AB + R_0' for span BC

$$= \frac{l_1}{\pi}\left(\frac{w_1}{1} - \frac{w_2}{2} + \frac{w_3}{3} - \frac{w_4}{4} + \frac{w_5}{5}\right) + \frac{M_A - M_B}{l_1} + \frac{l_2}{\pi}\left(\frac{w_1'}{1} + \frac{w_2'}{2} + \frac{w_3'}{3} + \frac{w_4'}{4} + \frac{w_5'}{5}\right) - \frac{M_B - M_C}{l_2}.$$

The deflections for the types of beams now being considered are obtained by superposing, upon the deflections of the simple beam, the deflections due to the negative B.M. applied at the supports. The trapezoidal B.M. figure, changing uniformly from M_0 to M_l, may be replaced by (*a*) a uniform B.M. of amount $(M_0 + M_l)/2$ causing deflections $-\frac{(M_0 + M_l)l^2}{144\,E\,I}$ multiplied by 5, 8, 9, 8, 5, for the five points of division of the span, $\frac{l}{6}, \frac{2l}{6}, \frac{3l}{6}, \frac{4l}{6}, \frac{5l}{6}$, respectively ; together with (*b*) a B.M. changing uniformly from $(M_0 - M_l)/2$ to $-(M_0 - M_l)/2$ and causing deflections $-\frac{(M_0 - M_l)l^2}{1296\,E\,I}$ multiplied by 10, 8, 0, −8, −10, respectively for the same five points of division.

Summary.—1. For a simple beam, if the intensity of loading is expressed as a sine series with the fundamental period equal to twice the span, then

similar sine series can be immediately deduced for the bending moment and deflection, and cosine series for the shearing force and inclination.

2. A scheme for obtaining the coefficients of the sine series in terms of the ordinates at each sixth of the span is explained and exemplified.

3. A table of bending moment or deflection at each sixth of the span can be obtained from the corresponding sine series by use of a scheme identical with that used to obtain the load series from the load intensity ordinates.

4. Formulæ are given for estimating the position and amount of maxima values, and also for estimating the effect of the load near the supports upon the bending moment and deflection.

5. The modifications in the theory are indicated which are necessary to render the method applicable to cantilevers, and to overhanging, continuous, and built-in beams.

DUPLEX COAL-BRIQUETTING MACHINE.

CONSTRUCTED BY MESSRS. SUTCLIFFE, SPEAKMAN AND CO., LIMITED, ENGINEERS, LEIGH, LANCS.

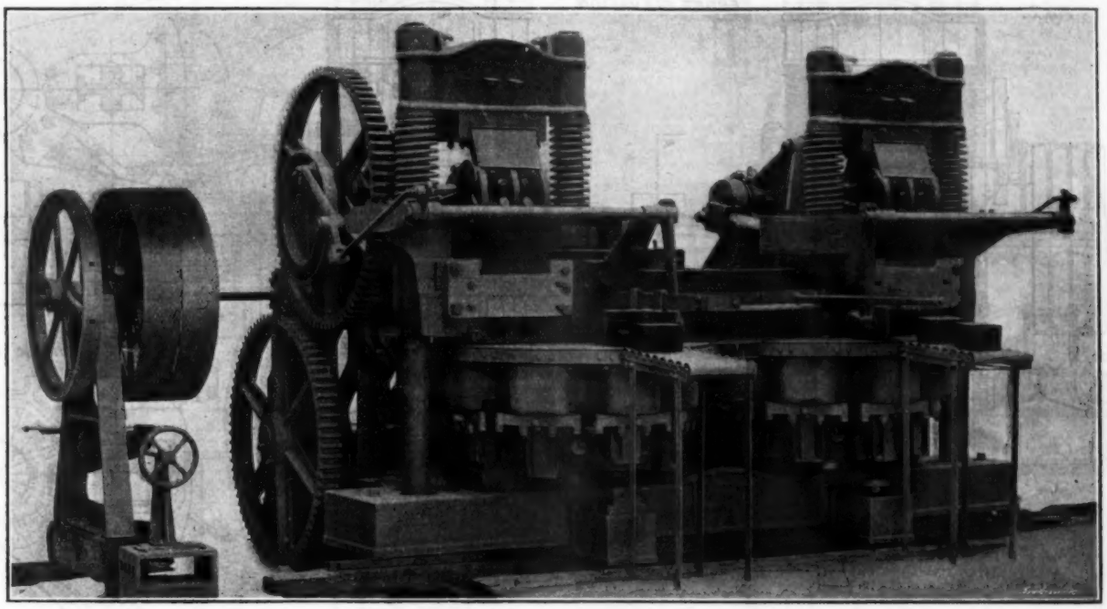


FIG. 1.

DUPLEX COAL-BRIQUETTING MACHINE.

THE briquetting of coal, ores, &c., is now an industry of considerable magnitude, and one which is extending, as the advantages which briquetting confers on many materials in respect of storage and transportation are more widely recognised. For some considerable time, Messrs. Sutcliffe, Speakman and Co., Limited, of Leigh, Lancashire, a firm with a large experience of briquetting machinery generally, have been occupied in research work relating to coal and, as a result of their experiments, they have redesigned and improved their "Emperor" type of briquetting press so as to fulfil the special requirements of the coal briquetting industry. The centre of this industry is in South Wales, and one of the large works in that district has recently been equipped with five briquetting presses of Messrs. Sutcliffe, Speakman and Co.'s latest design. These machines are interesting, not only as being probably the largest briquetting machines in the world, but also on account of their mechanical features. Each machine weighs about 32 tons, and exerts a pressure of 200 tons on the material. At a speed of 30 working strokes per minute each will turn out 40 tons of briquettes per hour with an expenditure of 48 h.p. The usual size of briquette is 11½ in. by 9 in. by 6 in., with a weight of 25 lb., but the dimensions and shape can, of course, be modified by the use of suitable moulds.

The general appearance of one of the machines is illustrated in Fig. 1, annexed, while Figs. 2 to 12 on pages 690 and 691, will make clear the details of its construction. The coal to be briquetted after being reduced to the required size and mixed with a small proportion of pitch, which acts as a binding material, is delivered continuously by a conveyor into the central feed pan. This pan, which is shown in plan in Fig. 3 and in section in Fig. 10, is 5 ft. diameter by 15 in. deep. It is made of mild steel with a cast-iron bottom, the latter being cut away in two places to clear the mould tables which rotate directly underneath. During the passage of the moulds beneath the pan they become filled with coal, a process which is rendered regular and certain by the action of rotating scrapers. The continued rotation of the mould tables brings the moulds under the presses which consolidate the briquettes. The latter are then ejected from the moulds and pushed off the tables on to roller conveyors which take them away from the machine. As the filling of the moulds and the pressing, ejecting and discharging of the briquettes are all entirely automatic, there is no difficulty in working the machine at the speed stated above, provided that it is fed with sufficient material, and that the briquettes are removed as fast as the machine discharges them. Successful operation at high speed is rendered possible by the use of machine-cut gearing throughout the machine, and by all workmanship and material being of very high grade so as to withstand the heavy stresses involved in high speed working. We may mention that all main shafts and bearings are ground to micrometer gauges, and other refinements of manufacture, quite unusual in machinery of this type are adopted.

Turning to a consideration of the illustrations, it will be seen that the whole machine comprises a pair of similar presses on a single bedplate and supplied with material from a feed pan common to both. Power for all motions is derived from a shaft running along the back of the machines, and driving each by a phosphor-bronze pinion. A pulley on the shaft drives the stirring arms in the feed pan by means of a belt and two pairs of bevel gear as shown in Figs. 3 and 10. Each press consists essentially of a pair of round steel columns united at the top and bottom by heavy cross-heads. The lower cross-head is rigidly fixed to the columns, being screwed up against shoulders on them by nuts with buttress threads. The upper crosshead is free to slide on the columns, its distance from the lower one being adjustable by means of the nuts at the top of the columns. The whole frame consisting of the columns and crossheads is attached to the main frame of the machine by links, as can be seen in Fig. 11, so that it has a certain amount of vertical motion allowed to it. Its weight is partly supported by the heavy springs upon which the upper crosshead is seen to be resting, and partly by a counterbalance weight fastened to an extension of the lower link. The springs mentioned take no part at all in the briquetting process, their function being entirely to relieve the weight of the frame.

Gearing with the upper part of the main driving pinion is a large spur wheel keyed to the end of a short crankshaft carried in bearings in the main frame. The crank-pin and connecting rod operate a toggle mechanism, as seen in Fig. 11. The lower toggle link is fixed to a block which cannot rise appreciably from its position over the mould table, while the upper toggle link is fixed to the top crosshead. It is thus clear that the rotation of the crankshaft will result in the rise and fall of the top crosshead and therefore of the whole moving frame, including the bottom crosshead. The latter carries a pressure-block which, on the upward stroke, comes into contact with a plunger hanging from the mould-box which is the operating position. Details of these mould boxes and plungers are given in Figs. 4 to 9. As the illustrations show, dual mould boxes may be employed if desired, two briquettes being then formed at each stroke of the press, instead of one briquette of nearly double the size.

The moulds in the table are slotted out to template, and are fitted with renewable phosphor-bronze liners machined to fit accurately in position. On the underside of each mould is bolted a cast steel plunger guide, which carries the plunger or plungers. These guides are slotted to template, and the plunger bodies are an easy sliding fit in them. The face of the table is covered with renewable phosphor-bronze wearing plates.

From the illustrations it will be seen that the plunger head is larger than the plunger body, so that when the plunger is at the bottom of the mould the head is retained by the cast steel guide plate. The method of placing and holding the liners in position will be readily understood from the detail drawings. The liners are machined to fit the moulds sideways, as has been stated, and each liner carries lugs cast on its ends, one of which lugs fits into a recess in the inner end of the mould. The liner is placed in the mould and the inner lug entered into its recess. A distance block is then placed between the outer end of the mould and the liner, and is driven down on to the lug at that end. The bolt holding the guide plate serves also to retain the distance block in position. The phosphor bronze cover plates are then screwed down on to the table, protecting the bolt heads and forming a smooth and level wearing surface. It will be noticed that the operation of replacing or changing liners can be easily and quickly performed, particularly as all liners are interchangeable and are machined to a template at the makers' works. The plungers are made of semi-steel, and are provided with renewable phosphor-bronze top plates, machined to a good sliding fit in the moulds.

Each of the mould tables is keyed to a heavy cast-

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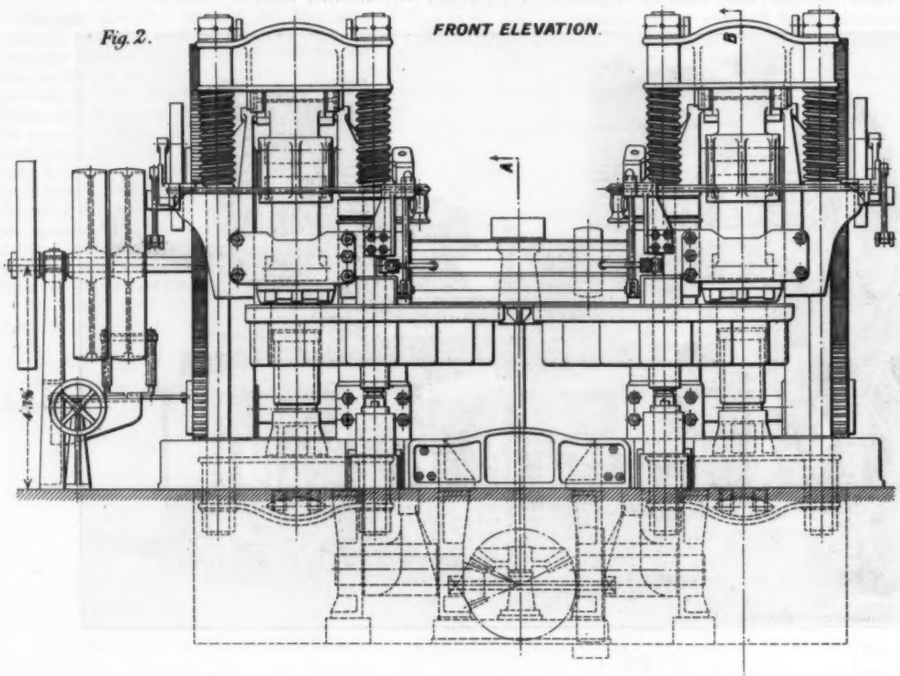

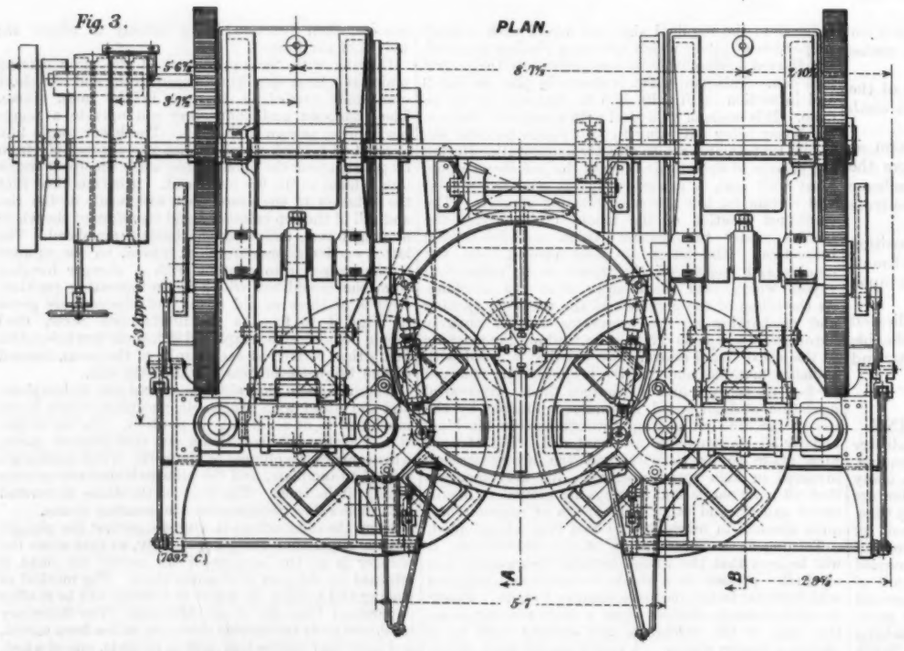

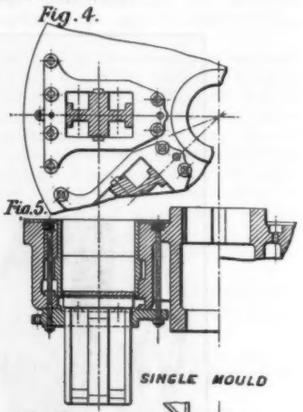

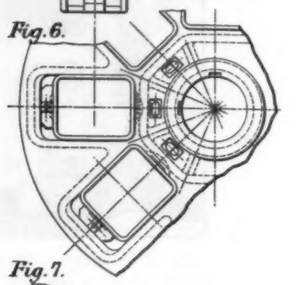

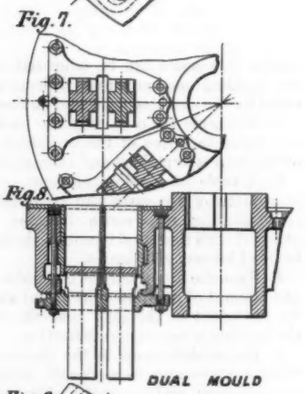

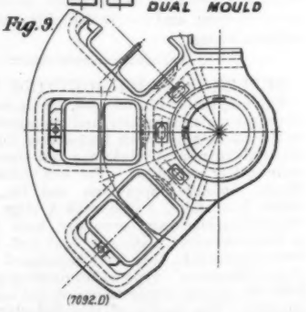

iron sleeve which embraces the inner column of the respective press, and is carried in a substantial footstep bearing on the bedplate. At the upper end of this sleeve is mounted the table-turning gear. This consists of a pawl and ratchet arrangement operated by an adjustable connecting rod driven by an overhung crank at the end of the crankshaft which works the pressing motion. The mechanism is so adjusted that at every complete revolution of the crankshaft, and therefore after every stroke of the press, the table is rotated through 45 deg. and another mould brought directly beneath the centre of the press. At the same time an empty mould is brought underneath the opening in the bottom of the feed pan and is filled with fresh material. At the back of the feed pan is an adjustable scraper, which is set down flush with the table top, so that any excess material which might be heaped up in the mould is scraped off by the motion of the table This ensures that the same amount of material is contained in each mould. Round the edge of the mould table is an adjustable band brake, the friction of which holds the table steady when it is at rest, and prevents any tendency to overrun its position which the speed of working might otherwise cause.

From the description so far given, we think it will be clear how the briquette moulds are filled and pressed. The briquettes formed as a result of these operations have, however, to be ejected from the moulds and removed from the machine. The ejecting mechanism is driven by the lower of the two large spur wheels behind each press. This spur wheel is keyed to a shaft at the other end of which is a large cam wheel, best seen in Fig. 11. This cam wheel operates a heavy cast steel rocking lever in the base of the machine. The front end of the lever is linked to a ram which slides vertically in a housing carried from the bedplate. At the proper time this ram is raised by the motion of the lever, and coming in contact with the lower end of the appropriate mould plunger, lifts the latter and so pushes the briquette out of the mould. The cam wheel is so proportioned that it causes the plunger to pause in its highest position for a sufficient time for the briquette to be removed by the discharging gear before it starts to return. It is also so arranged that the ram does not touch the mould plunger until after the table has come to rest, nor does the table start to move again until after the ram has ceased to make contact with the plunger.

The removal of the briquette, after ejection, is accomplished by another and smaller cam mechanism, best seen in Figs. 3 and 12. The cam is keyed to the

DUPLEX COAL-BRIQUETTING MACHINE.

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Fig. 10. SECTION ON A-A

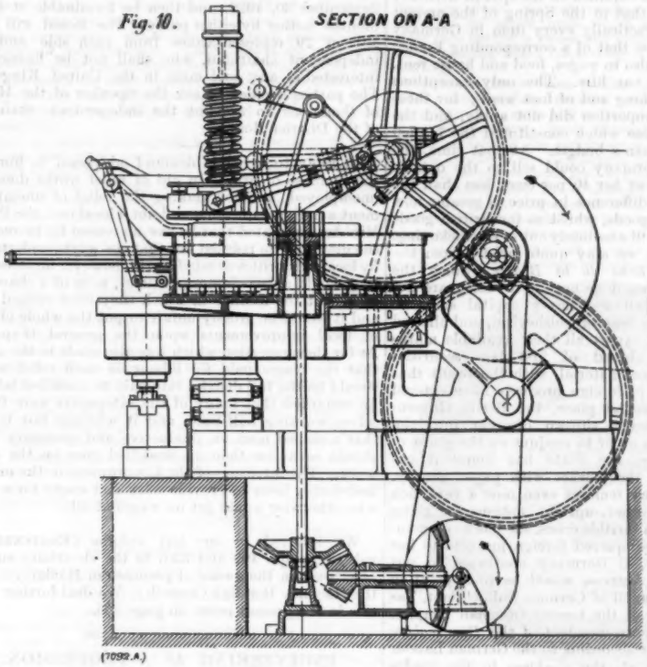
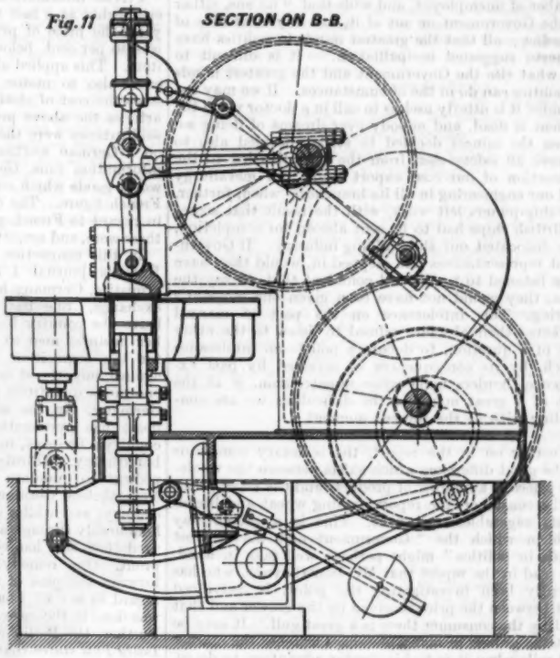
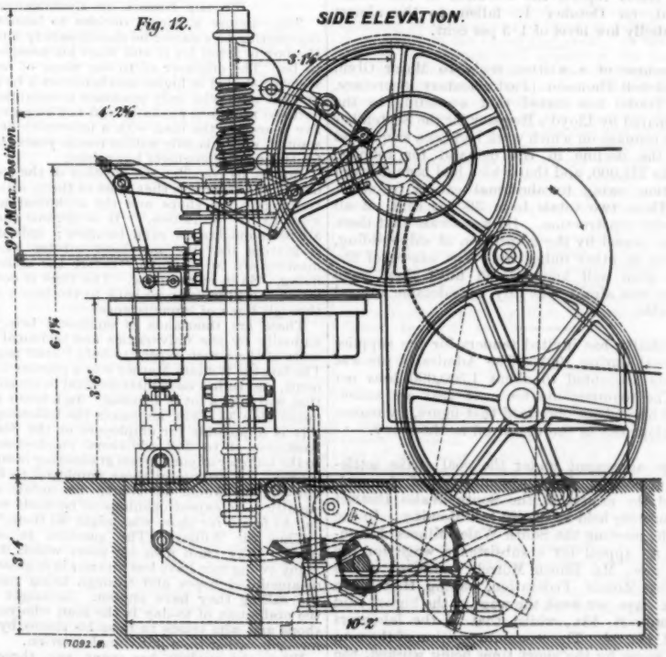


Fig. 11 SECTION ON B-B.



(7092.A.)

Fig. 12. SIDE ELEVATION.



(7092.B.)

crankshaft on the outside of the main spur wheel. By means of a system of levers and rods, the cam is connected to a push-off box, which has a to and fro' motion across the front of the table. The mechanism is so timed that when the briquette is being ejected the push-off box is situated behind the mould. Immediately the briquette is ejected the push-off box travels forward and pushes the briquette off the table. While this is happening both the table and the mould plunger are held at rest and remain so until ejection is completed.

Referring to the operation of the machine, it will be noted that as the mould plungers which compress the briquettes are brought mechanically to a definite height at each stroke, the thickness of the briquette made will be constant. By lengthening or shortening the effective length of the mild steel columns by adjusting the nuts holding the upper crosshead, briquettes of any desired thickness within reasonable limits can be made. As when once set, the machine must produce briquettes of constant thickness, then density will necessarily depend upon the quantity of material contained in the moulds. This is regulated by the position of the head of the mould plunger in the mould when the latter is being filled. To make briquettes of greater or less density, packing pieces are removed from, or added to, the underside of the plunger heads, thus increasing or diminishing the volume of material, which is contained in the mould before briquetting.

Standing as it does, some 9 ft. high from the floor level, and extending downwards several feet into a pit beneath, the machine is of a very impressive character, a feature which is enhanced by the massiveness of its construction. At the invitation of Messrs. Sutcliffe, Speakman and Co., Limited, we visited their works to inspect the last of the set of five which they have constructed. It was naturally impossible to see it actually at work making briquettes, as there were no facilities for the supply of the necessary material in sufficient quantities, but it ran light at its highest speed with a most satisfactory absence of noise or vibration, and gave the impression that it was in every way suitable for its duties.

IMPORT OF COAL AND COKE IN DENMARK.—An official statistical statement shows that the import of coal and coke into Denmark in the first eight months of 1921 amounted to 1,057,962 tons, as against 1,188,210 tons in the same period of 1920, says the *Danish Foreign Office Journal*. This year about 162,000 tons have been imported from the United States, and about 20,000 tons from Germany, while the rest has come from Great Britain. The Northumberland and Durham districts have been the chief exporters to Denmark, and together have supplied about 471,000 tons. The import of coke and cinders totalled 222,258 tons, as against 248,758 tons in the corresponding period of last year.

THE BRISTOL "JUPITER" AERO ENGINE.—The Bristol Aeroplane Company, Limited, Filton House, Bristol, inform us that their 400-h.p. air-cooled radial engine has recently satisfactorily completed the Air Ministry (March, 1920) type test, which has only previously been passed by two other makes of aero engines, both of the water-cooled type. The trials included high-power and high-speed tests, a 50 hours' endurance test, slow-running tests, accelerator tests, &c., some of which were carried out with a Heenan and Froude dynamometer and others in a hangar with a propeller in accordance with the provisions of the type-test schedule. Afterwards, full throttle tests were carried out, and the engine was also run for an hour with three of its nine cylinders cut out. In the full-throttle tests the engine developed a maximum of 462 b.h.p., at 1,875 r.p.m., with a fuel consumption of 0·566 pint per brake horse-power per hour, the fuel used being a mixture of 80 per cent. Aviation spirit with 20 per cent. benzol. The average consumption throughout the previous test was 0·594 pint per brake horse-power per hour, while the corresponding figure for lubricating oil was 0·049 pint per brake horse-power per hour. These consumptions, it should be noted, will compare favourably with those obtained from modern water-cooled engines. The official weight of the Bristol "Jupiter" engine complete is 729½ lb., excluding exhaust pipes and intakes, which works out at about 1·82 lb. per horse-power on a 400-b.h.p. basis. In addition to this obvious advantage of light weight, the engine is claimed to have fewer parts than any other aero engine of equal power, and it is also stated that it can be dismantled and re-erected in considerably less time than is possible with other engines.

INDUSTRIAL NOTES.

The eighty-eighth quarterly report, to September 30, recently issued by the General Federation of Trade Unions, refers in its opening lines to the very great number of unemployed, and adds that "no one, either in the Government or out of it, has any clear idea of remedies; all that the greatest minds in politics have hitherto suggested is—palliation." It is difficult to see what else the Government and the greatest minds in politics can do in the circumstances. If we may use a simile, it is utterly useless to call in a doctor when the patient is dead, and nobody ever dreams of doing so. When the miners decided to strike, decided also to remove all safety men from the pits, this led to the dislocation of our coal export trade, our metallurgy and our engineering in all its branches; when, further, the ship-joiners left work, with the result that scores of British ships had to be sent abroad for completion, this dislocated our shipbuilding industry. If Government representatives had stepped in, would they have been listened to? We feel confident that, to say the least, they would not have been given one moment's hearing. This intolerance on the part of manual workers—their absolute refusal to listen to the other side of a question, to debate a point—an intolerance which, by its consequences as revealed by past experience, borders upon utter unpatriotism, is at the root of a great many of the difficulties we are contending with at the present moment.

Further on in the report, the secretary complains of the great difference which exists between the wholesale prices of a number of products and the retail prices to the consumer, the report naming wheat and bread, meat, vegetables and fruit. This is a present-day problem which the "Government and the greatest minds in politics" might perhaps well take in hand. We read in the report that Mr. Ivor Gwynne, who has recently been investigating the point, is convinced that between the price received by the grower and that paid by the consumer there is a great gulf. It may be that the grower in many instances watches the market and sells when it is to his greater advantage to do so, just as any workman, manual or otherwise, deals with his own commodity, but this is somewhat of a side question. It is satisfactory to know, however, that the point is receiving attention, and it is to be hoped that the gulf referred to may be bridged soon.

According to the secretary of the General Federation of Trade Unions, it is to lower taxes and lower prices that we must look for improved conditions, and he is quite right, although his enunciation of the problem is only a partial one, for lower prices involve lower wages and also harder work. Thrift, moreover, would be sure to play a most important action in the improvement of conditions we all look to, for the losses which go on day by day in the average household, of every class, throughout the country are extensive in the extreme. It is stated that at the time when the miners were earning very heavy wages, a miner's wife purchased two grand pianos in order to outdo her neighbour who had purchased one. This is, no doubt, simply a story of the *ben trovato* order, but the mentality it indicates is not confined to the manual labour class, since as a very general rule the private individual personates the knight, the knight the baronet, and so forth, the result being a balance on the debit side in the household budget.

The report for October of the United Patternmakers' Association refers to the late ballot concerning the withdrawal of the 12½ per cent. and 7½ per cent. war-time bonus. It gives the result of the ballot taken by the Joint Committee of Light Metal Trade Unions, adding that "ballot papers were issued to our Falkirk, Bonnybridge and Bo'ness members." Of these, there voted 125 for the reduction and 31 against, a total of 156 votes, out of a total membership for the three branches of 307. Members to the number of 151 did not take the trouble to vote; they were, presumably, in favour of the reduction, and their number, added to the 125 who voted in favour, gives a total of 276 out of the total of 307 members for the branches in question. Taking the figures given in the report for the ballot of the patternmakers as a whole, there voted 3,725 for the reduction and 2,632 against, a majority for of 1,093, the number of voters being 6,357 only, out of a total membership of 12,781. On the plausible basis we have taken above for three small branches, over three-quarters of the patternmakers were in favour of the war-time bonus withdrawals. This result refutes completely the inordinate statement made in another part of the report, "the deliberate refusal on the part of the employing and rentier classes to pool their resources in the interests of all, this, under present conditions, leaving them with no alternative but to crush down the essential workers to a lower standard of living . . ." The letters from several individual members printed in the report, concerning the association's expenses and the "appeals which are made in support of the outspoken labour newspaper, the *Daily Herald*," are decidedly interesting reading.

Private information obtained on the spot in Germany establishes as a fact that in the Spring of the present year, the price of practically every item in Germany was 40 per cent. below that of a corresponding French item. This applied also to wages, food and house rent, even also to motor car hire. The only exceptions were the cost of clothing and of foot wear; for these articles the above proportion did not apply, and the said articles were those which constituted the burden on a German workman's budget. At that time, the information runs, Germany could sell to the outside world goods which cost her 40 per cent. less than the French figure. The difference in price is greater now in regard to French goods, whilst as for British goods these were, and are, still absolutely out of the reckoning.

In this connection we may quote briefly from the Brussels journal *L'Echo de la Bourse*. Since the armistice, Germany has done nothing to safeguard her exchange. She has allowed heavy capital sums to leave the country for fear of bolshevism, and allowed her business men to export all their available marks for the acquisition abroad of first-class securities against imports of raw material, with the result that enormous quantities of foreign products have entered Germany. In the second place, the Berlin Government has systematically thrown disorder into the country's finances, in order to conjure up the ghost of bankruptcy. Thirdly, the State has found it expedient to inundate the market with paper money. Nevertheless, Germany remains even now a very rich country, and whilst other, upright, nations are going honourably through a terrible crisis, she has so manœuvred that she has conquered foreign markets to her profit. One remedy, if Germany continues to put forward the plea of distress, would be to appoint in regard to her a "Council of German Public Debt," as was done in the case of the former Ottoman Empire. Further, the Berlin correspondent of the *Birmingham Daily Post* states that according to the German Labour Ministry's latest report, the workless in the trades unions had, on October 1, fallen to the almost unprecedentedly low level of 1·3 per cent.

In the course of a written reply to Major Glyn, Sir W. Mitchell-Thomson (Parliamentary Secretary, Board of Trade) has stated that according to the returns prepared by Lloyd's Register for the September quarter the tonnage on which work had been suspended owing to the decline in the demand for tonnage amounted to 731,000, and that which had been delayed in completion owing to abnormal causes to about 457,000. These two totals form 36 per cent. of all tonnage under construction. He was aware that there was distress caused by the suspension of shipbuilding, as there was in other industries. The causes of the suspension were well known, and until these were removed he was afraid that any considerable revival was impossible.

The Admiralty has invited tenders for the supplies of Welsh coal during 1922. The Admiralty pre-war requirements amounted to about 1,500,000 tons per annum. The requirements for next year are anticipated to be only about one-third that figure, by reason of the development in the use of oil in the Navy.

The wage agreement under the coal strike settlement was signed by the representatives of the coal-owners and the miners in the South Wales District area at a meeting held at Cardiff last Monday. In the course of the meeting the South Wales Miners' Executive made an appeal for a subsistence wage for the lower-paid men, Mr. Enoch Morrell, president of the South Wales Miners' Federation, saying that when working six days per week the wage of the higher-paid men was only 2*l.* 13*s.*, whilst that of the labourers was only 1*l.* 18*s.* 6*d.* The economic position of the men was made worse by the short time being worked, the average not exceeding four days per week. The position of the lower-paid men was worse still; thousands of these were averaging less than 1*l.* per week in wage. Mr. Evan Williams, in reply, stated that the coal-owners regretted they were unable to do anything substantial in the way of meeting the appeal, owing to the bad economic position of the coal industry. Any addition to the wages of the lower-paid men would have to be paid out of the owners' pockets. If the men's representatives continued to press their claim and made definite proposals as to what they regarded as a subsistence wage, the owners would be prepared to meet them. If an agreement could not be arrived at as to what was a subsistence wage, the point would have to be referred to the independent chairman of the Board for decision. The decision would be honoured by the owners even if they had to pay the money out of their own pockets, but he warned them that the payment of a higher wage might result in the closing down of some collieries which were now working at a loss. The parties then considered the terms of the agreement, which, it was decided, should run concurrently with the national agreement until September 30, 1922, and then be terminable at three months' notice by either party. The Board will consist of 29 representatives from each side and an independent chairman, who shall not be financially interested in any coal mine in the United Kingdom. The parties decided to ask the Speaker of the House of Commons to appoint the independent chairman of the District Board.

In reply to a recent demand addressed to him for the increase of grants in aid of relief works done by unemployed, and for making the relief of unemployment a national question and not a local one, the Prime Minister has stated that he saw no reason for increasing the grants. He pointed out that the works undertaken by local authorities as relief works, however unnecessary they would appear in normal times, were of a character to benefit the locality in which they were carried out, and it would be grossly unfair to put the whole charge of local improvements upon the general taxpayer. As for the suggestion which was also made to the effect that the wages paid for labour on such relief works should be the full district rate paid to unskilled labour, he remarked that many of the ratepayers were themselves working half-time, and it was not fair to ask that a skilled man on productive and necessary work should earn less than an unskilled man on the relief work. The intention of the Government in the matter had simply been to provide work and wages for a man who otherwise would get no wages at all.

We referred in our last volume (ENGINEERING, vol. cxi, pages 499 and 550) to the electricity supply case between the owner of premises in Hackney *versus* the Hackney Borough Council. We deal further with this in the present issue, on page 705.

ENGINEERING AS A PROFESSION.

To the Editor of ENGINEERING.

SIR,—Before a parent decides to launch a son into engineering as a career he should satisfy himself whether the boy is fitted for it and what his prospects are likely to be. The engineer of to-day must of necessity be a scientist skilled in higher mathematics if he is to succeed, and the man who only possesses manual dexterity must perforce remain a producer and not a creator. Twenty-five years ago the man with a university degree was not wanted, and it is only within recent years that a demand for this type of engineer has arisen.

But let us consider the position of the engineer of to-day. The trouble is that most of them, after an arduous training in the shops and the technical school, do not want to be "workmen." It is obvious that we cannot all be managers, or even foremen; indeed engineering is getting like the merchant service where qualified masters are to be found "before the mast" to earn a living. So in engineering. The time is coming when a lot of us will have to go back to the bench and the lathe through force of circumstances.

There are thousands of engineers being turned out annually by the universities and technical colleges, and most of these men expect to hold "staff appointments." The late Sir William Mather was a pioneer of this movement, and he has been instrumental in creating a monster that will take a lot of housing. In a letter to the writer, dated May 30, 1910, he makes the following statement: "It is impossible for employers or the State to create vacancies or to find additional employment according to the number of young men graduating from a university course. To dispose of those employed to find room for new-comers would of course be unfair and unjust; equally so to expect openings to be made when no work can be found for those who might fill them."

Thus Sir William. The question at once suggests itself: Why train men for posts which do not exist? Many young men have lost interest in engineering through disappointed hopes and through being trained beyond the calling they have chosen. As might be expected the craftsman of to-day is the man who remains in the shops and who trusts to raise his status by trade union methods rather than individual exertion.

When the student has spent, say, three years on a course qualifying for a degree, and another three years in the workshops—six years of heavy expense and work without appreciable remuneration—he finds himself at man's estate in a market where the supply exceeds the demand. As it is the need of reward that makes us labour one expects to be adequately compensated, but this is not so among the bulk of educated engineers to-day. For instance, there have been recently vacancies for research men, and the salary has been fixed at 350*l.* per annum—far less than the earnings of a dud plumber. Considering the cost of a university education and the cost of one's keep during this period, and the subsequent apprenticeship, is it not reasonable to expect, say, a 5 per cent. return on this capital outlay?

How often do we find in advertisements, "Apply with references stating experience *and salary required*?" Tell your prospective employer you want five hundred, you are worth it and can earn it, and he will not only not believe you, but he will give the job to the man who is satisfied with three hundred. An engineer is on a level

with a domestic servant, he has to carry his references and produce them on demand, and he stands to have his career ruined by a boss with whom he cannot hit it off. We all know of cases where the man who is not, or cannot, be a sycophant, and therefore has to quit his job. And we all know instances, in other walks of life, of mediocre people who have the goodwill of influential men and who profit thereby. We know of men who, by their personality, assurance and swank conceal their ignorance or incompetence. Then there is the man with knowledge, ability and trained intellect who cannot sell his goods because, for some reason, he cannot get a hearing. It pays to cultivate influence, and time so spent is used to better advantage than if expended on the study of the calculus.

There are many people with boys of a mechanical turn of mind, and when approaching the time for choosing a career engineering is decided upon. Generally neither the parents nor the boy know what is required of the engineer of to-day, or that it may be imperative to go abroad in order to command a reasonable salary; therefore it behoves parents to consider carefully before letting their boys take up this calling. No business or profession requires more diligent study from beginning to end; further, the remuneration is woefully inadequate, even if one is fortunate enough to rise to a position of eminence.

If engineers continue to be paid as they are at the present time the profession will cease to attract the right men, unless, of course, they possess private means. The result will be they will take their brains to other countries where they will be better appreciated. The other two factors, unemployment and overcrowding, also require the most earnest consideration. There are hundreds of highly-trained engineers all over England who cannot find work for these reasons. Other men have forsaken their profession to embark in business or commerce; they have certainly bettered themselves financially, but their scientific attainments are wasted and lost to the nation.

Yours truly,
"SLIDE RULE."

"AN INVESTIGATION OF HOT-DRAWING ON THE MANDRIL."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to your abstract of the paper read at the Paris meeting of the Iron and Steel Institute, on Tuesday, September 6, by Mr. Eugene Schneider, it would appear especially from the introductory paragraph that the subject-matter of this paper was presented as a novel investigation into the theory of hot drawing, whereas, as long ago as the early months of 1919, the theory underlying the process of hot drawing was enunciated in detail and published, together with many other investigations relating to the hot working of steel, in my book on "Practical Shell Forging and the Plastic Deformation of Steel and its Heat Treatment."

In the latter work will be found the explanation as to *why* tearing occurs at the die, when the entrance angle exceeds a certain definite limit, and the conditions of equilibrium of the metal at the entrance angle of the die is presented graphically.

It would also appear from your abstract that no account has been taken of the very careful research undertaken by Messrs. Rosenhain and Humphrey on the tensile strength of mild steel at high temperatures, in which it was shown that the tenacity of hot mild steel *does not* follow a uniform curve, but that there is a critical range below 1,000 deg. C. and above the recalescence temperature, wherein there is a marked discontinuity of the tensile curve. The reference given in your abstract in column 3, page 680, as to the value of ϕ often in practice exceeding the breaking stress, appears much more in conformity with the results of the above research, to which it is reconciled in my treatise, than to the explanation offered. As the result of experience of the production of some 15,000,000 shell forgings during the war, it was found that the conical die entrance is to be preferred to the curved die entrance allocated by Mr. Schneider; the reason for this will become apparent when it is considered in the light of the limiting entrance angle, inasmuch that with a curved entrance angle, the angle *increases rapidly* with any increase of the wall thickness of the forging, whereas with the conical die, the angle remains constant. It may be said that the conditions enunciated are for definite wall thicknesses, but anyone who has had experience in hot drawing knows that in practice there is almost invariably some eccentricity of the forging walls, unless carefully trued by turning after piercing and before drawing.

Yours faithfully,
CLIFFORD D. BOWES.

A FUEL INDICATOR.

TO THE EDITOR OF ENGINEERING.

SIR,—During a recent visit to the Berlin Motor Show, the writer encountered a rather novel form of fuel indicator which fulfilled the duel purpose of recording the amount of fuel consumed and the amount of fuel still left in the tank. The instrument is fitted in conjunction with the "Pallas" system of vacuum feed and is operated through the medium of a tube which is connected with the vacuum feed apparatus.

The following description explains the action of the instrument in use and the way in which readings are taken. The meter face is circular and has a circular scale reading from 0 to 100 set at a short distance inward from the periphery of the face. A further circular scale is arranged around the chart before referred to, and its readings are from 100 to 0, that is to say, whilst the readings on the inner chart increase when moving over it in a clockwise direction, the readings on the outer chart decrease. A finger moves over the inner chart under the action of the counting mechanism. The outer chart is secured upon a ring capable of rotary movement on the outside of the meter. This ring carries the glass face of the meter and the outer chart which is provided upon the glass. At zero reading on the outer chart is provided an arrow head which is coloured red. The glass face carries a projecting element which can engage the indicating finger for setting it at any desired initial reading.

Upon the meter face is also provided a liquid fuel total consumption counter reading in thousands, hundreds, tens, units and tenths of a litre, gallon or other standard measure. Each alternate odd section of the tenths section of the indicator is coloured red, so that on the stroke of the diaphragm under the action of the vacuum on the vacuum feed apparatus, the red colour is shown, whilst when the diaphragm returns to its initial position, which corresponds with the period of atmospheric pressure and delivery from vacuum feed apparatus, the tenths indicator exhibits a number.

In use the finger is set at zero on the inner chart or scale and the outer chart or scale is turned till the arrow

head points to the number on the inner scale corresponding to the number of litres or gallons which have been placed in the liquid fuel tank. As the fuel passes through the vacuum feed apparatus, the finger travels in a clockwise direction and the readings on the inner scale indicate the amount of fuel consumed and on the outer scale the amount of fuel still in the tank.

By the arrangement of the alternate coloured and numbered tenths section of the dial and by the provision of the coloured arrow head on the outer scale which the finger approaches as the supply of fuel becomes exhausted, the user of the motor vehicle to which the vacuum meter is fitted has indications that the vacuum feed apparatus is working and that the supply of fuel needs replenishment.

Although the instrument described above has been designed for use with the "Pallas" fuel feed system, an instrument operating on the same principle could be made to work in conjunction with any given vacuum feed system. The sole distributing rights for this instrument are held by Herr Maurice Talbot, Romain Talbot, Berlin S, 46, Wassertor-str.

Yours faithfully,
J. L.

"AIR LIFT PUMPING."

TO THE EDITOR OF ENGINEERING.

SIR,—I have been greatly interested in Dr. John S. Owens' paper on "Air Lift Pumping," reported on page 458 of your issue of September 23 last, but as he has referred to some of my earlier work and drawn some misleading deductions and comparisons with it, I would ask your leave to correct these.

Firstly he refers in the second paragraph of his paper to efficiencies obtained and reported on various occasions, and points out that I recorded some such, measured as between water horse-power and air horse-power, of 22·5 to 36 per cent. Now the air horse-power in these cases was clearly stated to be the indicated horse-power of the air cylinders of the air compressor. Dr. Owens, however, in his tests uses the term air horse-power to define the energy contained in the air when entering the foot-piece. As I have pointed out elsewhere this, even with a good compressor, is only about 60 per cent. of the former. It is unfortunate therefore that scientific men should compare two such different standards of efficiency without making the point quite clear that they are so doing. The lack of a standard nomenclature and standard of efficiency for air-lift pumping is doing more perhaps to delay its due development than all other causes.

As I showed in my paper before the Institution of Mechanical Engineers in November, 1917, efficiencies of 72·4 per cent. based on the standard used by Dr. Owens have been obtained on a lift of 300 ft. in one stage. These, however, are nowhere referred to by Dr. Owens.

Secondly, in the discussion Dr. Owens is reported as saying that the displacement theory of the action of the air-lift pump implies large pistons of air. Nothing is further from the facts, and I not only do not believe the theory that the air acts in the form of large pistons, but in the paper above referred to I laid considerable stress on the advantage of keeping the air in small bubbles. The displacement theory only amplifies the theory approved by Dr. Owens, but approaches it from a different angle from that taken by him.

I would ask Dr. Owens to re-read my paper as he evidently has only done so in a hurry, and entirely missed both the main theoretical deductions and the results of tests there reported. In conclusion I would like to congratulate Dr. Owens on the research work done by him on the slip of air bubbles through water, as such information is what the problem of air-lift pumping most requires at present.

Yours faithfully,
A. W. PURCHAS.

Chasewood, Hessle, E. Yorks., November 14, 1921.

"STRESSES IN SHIPS' PLATING DUE TO FLUID PRESSURE."

TO THE EDITOR OF ENGINEERING.

SIR,—May I ask your indulgence by allowing me to make a brief reference to Professor Abell's letter contained in your journal of the 28th ult. His letters are certainly remarkable, and his latest, perhaps, even more surprising than the first.

Innuendo, forsooth! Not even by the merest fancy can the term be applied to anything I have said; but as the professor has chosen to introduce the expression, amongst others, I would ask him to go carefully over his first letter and see if much of its contents could not be placed under that category. Letters so framed, apparently in a vein of captious criticism, can never take us far forward in the discussion of this or any other problem.

I am, yours faithfully,
B. C. LAWS.

"Claverton," Sutton, Surrey, November 8, 1921.

ROYAL METEOROLOGICAL SOCIETY.

THE first monthly meeting of this society for the present session was held on Wednesday, the 16th inst., at the society's new house, 49, Cromwell-road, South Kensington, Mr. R. H. Hooker, M.A., president, in the chair. The following papers were read:—

1. Dr. Harold Jeffreys: "*On the Dynamics of Wind.*" It has been found that winds can be divided into three main groups, according as the pressure differences between places at the same level are mainly occupied in producing acceleration relative to the ground, in guiding the wind under the influence of the earth's rotation, or in overcoming friction. Those of the first class are called Eulerian, the second "geostrophic," and the third "antitriptic." It is shown that tropical cyclones and tornadoes are Eulerian, while all winds of wide extent, from the travelling cyclone of temperate regions to the general circulation, are approximately geostrophic, and sea and land breezes and mountain and valley winds are mainly antitriptic. It is shown that temperature differences are capable of accounting for the annual pressure variation in Asia, and probably for the permanent winds of Antarctica, and theories of mountain and sea breezes are given that in the main agree with the facts. In both the latter cases a fundamental part is played by the deviation of the actual average temperature lapse rate from the adiabatic value.

2. N. K. Johnson, B.Sc.: "*The Behaviour of Pilot Balloons at Great Heights.*" The determination of the wind structure in the upper atmosphere is almost invariably performed by following a pilot balloon by means of a theodolite. At a few stations the balloon is followed by two theodolites situated at the ends of a base line, but the great majority of the determinations are by single theodolite pilot balloon ascents. The reduction of a single theodolite pilot balloon ascent rests fundamentally upon the assumption that the rate of ascent of the balloon is uniform. Any departure from uniformity in the rate of ascent will give rise to errors in the computed wind velocity and direction. In the case of a pilot balloon observed with two theodolites at the ends of a base line, the actual height of the balloon is calculated from minute to minute, and no assumption is therefore needed as to the constancy of the rate of ascent. On the contrary, this method affords a means of testing the accuracy of the assumption which has to be made in the single theodolite method. Evidence bearing on this point is given by the results of two theodolite observations made at Shoeburyness during 1920, and examples are given which illustrate the untrustworthy nature of the single theodolite method of observation at great heights. Experiments on the leakage of pilot balloons are detailed, and from these the author reaffirms that the results of single theodolite pilot balloons ascents which are carried to great heights must always be received with great caution.

3. C. J. P. Cave, M.A.: "*The Cloud Phenomenon of November 29, 1920.*" On November 29, 1920, a cloud with a sharp-cut edge passed across the east of England, and was observed as far north as Worksop, Notts, and as far south as Hawkhurst, Kent. The cloud moved from the west, in front the sky was clear, behind completely overcast. The progress of the front has been mapped from sunshine records and observers' notes, and the upper air conditions have been investigated.

AERIAL NAVIGATION.—The journal *L'Exportateur Français* states that every effort must be made by France to develop her aerial navigation system, and adds that in the future the nation who has "the mastery in the air" will be prominent above all other nations. The public should utilise largely aerial means of locomotion, which are now as safe as all other means, and Parliament should grant the necessary credits for the development of commercial aviation.

THE NORDBERG WINDING ENGINE.

(*Continued from page* 630.)

Steam is distributed to the cylinders by means of two throttle valves for the high-pressure cylinders, and in addition two semi-rotative throttle valves on the low-pressure cylinders, all operated by servo-motor. The object of the additional valves on the low-pressure cylinders is to enable the operator to shut off steam from all cylinders so as to prevent any movement occurring due to the expansion of steam between the high-pressure and low-pressure cylinders, when the main throttle is shut. The low-pressure throttle makes the control of the hoisting engine much more prompt. The high-pressure throttle valve is illustrated in Fig. 57, Plate XL. It is a single beat valve of the balanced type. From the section given it will be observed that the valve proper is a tube, the bottom end of which is coned and rests on a ring seat. The valve stem is attached to the upper end by a plate and studs. The tubular body of the valve is bored out to fit a piston head forming part of the seat casting. This head is provided with two well fitting packing rings as shown; the internal bore of the valve body is 10⅛ in., and the valve seating is ¼ in. wide. The upper side of the stationary piston is under the same pressure as the end of the valve, on account of communication between the two spaces by way of holes in the plate forming the upper end of the tubular body. The valve is therefore practically balanced except for the small annular surface ¼ in. wide forming the seat. This type of valve is said to work very freely and to keep quite tight. The cylinder lubrication is introduced by a pipe shown in the section in Fig. 57. The oil drops on the edge of the valve, and some of it passes down to lubricate the throttle piston. The low-pressure throttle valves are of the semi-rotating type contained in the cylinder casting. These valves are not illustrated in detail.

The high-pressure cylinders are of the type shown in Figs. 59 to 67, Plate XL. The positioning of these cylinders will be followed on reference to the small key, Fig. 65. These cylinders are set at 22½ deg. to the vertical, the actual direction of the vertical through the centre being shown by the diagonal line in Fig. 58. An outside half end view is shown in Fig. 59, while Figs. 60 and 61 shows a cross section through the valve, and Fig. 62 a cross-section in the central part showing the steam chest and below the exhaust passage. A half-longitudinal section and outside view are given in Fig. 63, and Fig. 64 gives an outside view of one end and a section along the line CD (Fig. 58). The cylinders are steam jacketed throughout, with jacketed covers. Live steam is used for this purpose. The high-pressure cylinder jackets are formed by the cylinders being fitted with liners. The valves for all cylinders are of the Corliss type. In the case of the high-pressure cylinders the inlet valves, of which a section is given in Fig. 66, are quadruple ported, while the exhaust valves, shown in Fig. 67, are double ported. The high-pressure cylinders are 28 in. in diameter, and the clearance volumes work out as follows:—

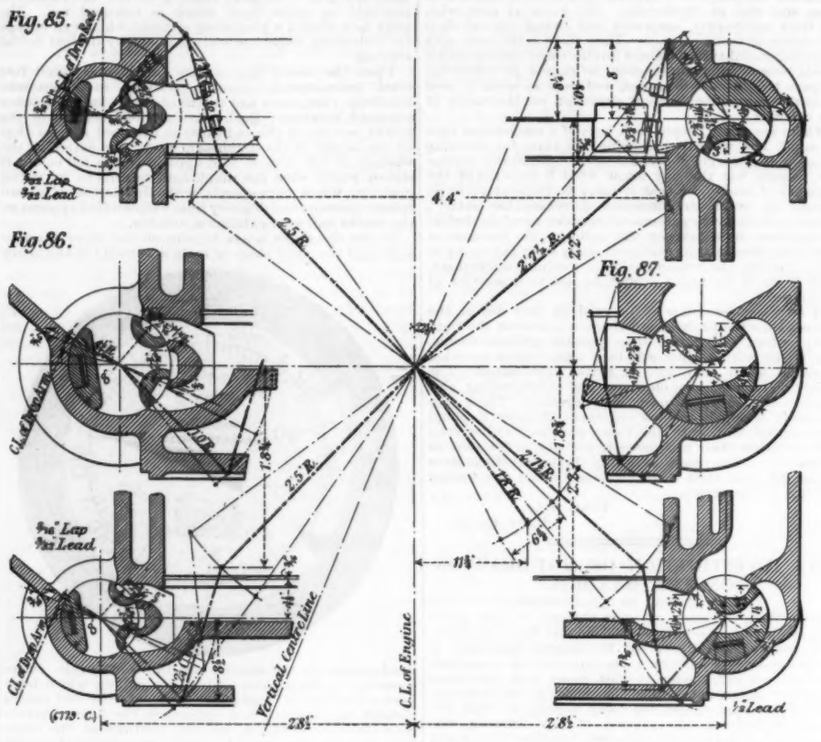
	Cub. in.
Steam port	275
Exhaust port	485
¼ in. end clearance	154
Steam valves	35·4
Exhaust valves	413
Head recesses	151·5
By-pass	66
Total	1,579·9

This amounts to 6·1 per cent. of the volume swept through by the piston for 28-in. stroke.

The low-pressure cylinders are illustrated in Figs. 68 to 74, Plate XL. In these the jackets form part of the casting, which also is arranged to house the semi-rotating throttle valves in a steam chest shown below the castings, as they are drawn in Figs. 68, 70 and 71. The drawings show various sections and outside views as follows: Fig. 68, a half outside view and half-longitudinal section, the right-hand end of Fig. 68 being actually the bottom end of the cylinder as mounted in the engine. Fig. 69 shows a half plan from the top; as shown in the figure the admission valve is below, and the exhaust above. The right-hand half of Fig. 69 shows a cross-section through the valve chambers. Fig. 70 is a half section through the centre of the cylinder, and Fig. 71 shows the bottom end partly broken away to show the rest of the throttle chamber. Fig. 72 shows a quarter outside view on the exhaust side, and a section taken along the axis of the cylinder, the right-hand end being the bottom end on the engine. The low-pressure cylinders, as already stated, are 52 in. in diameter. The clearance at each end allowed is ¼ in. The area of the steam port is 133 sq. in., and of the exhaust port 165 sq. in. The clearance volumes for each low-pressure cylinder works out as follow:—

DETAILS OF COMPOUND WINDING ENGINE.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.



	Cub. in.
Steam port	536
Exhaust port	1,345
Steam valve	128
Exhaust valve	1,125
Cylinder head	314
By-pass	140
Counter bore	536
Total ...	4,124

This is equivalent to 4·61 per cent. on the 42-in. stroke volume for the bottom end. Sections of the ports given in Figs. 73 and 74 show respectively the exhaust ports for valves, 9 in. in diameter, and the steam ports for valves, 8 in. in diameter. The valves are of the same type as those used on the high-pressure cylinders. Sections showing the low-pressure valves in their relative positions are given in Fig. 85 above, and in the views drawn to a larger scale, Fig. 86, showing a steam valve and Fig. 87 showing an exhaust.

The valve gear of the engine provides for an extended range of cut-off, from zero to nine-tenths of the stroke. The gear is very similar to the Frickart gear, a separate eccentric being used for operating the trip gear. In the Frickart gear the movement of the auxiliary eccentric is transmitted directly to the trip hook on a reduced scale. On account of the valve friction there is a good deal of drag on the trip, and this necessitates a heavy governor. In the gear adopted on the engine we are describing, this drag has been eliminated by means of the device illustrated in Fig. 88, 89 and 90, on page 695. Fig. 89, as will be evident, is a detail of the trip to a larger scale. Fig. 88 shows the wrist plate and diagrammatically the crank, eccentric circles and linkage. A separate knock-off eccentric is furnished. The whole gear may be followed in Fig. 7, Plate XXXII, published with our issue of the 21st ult.

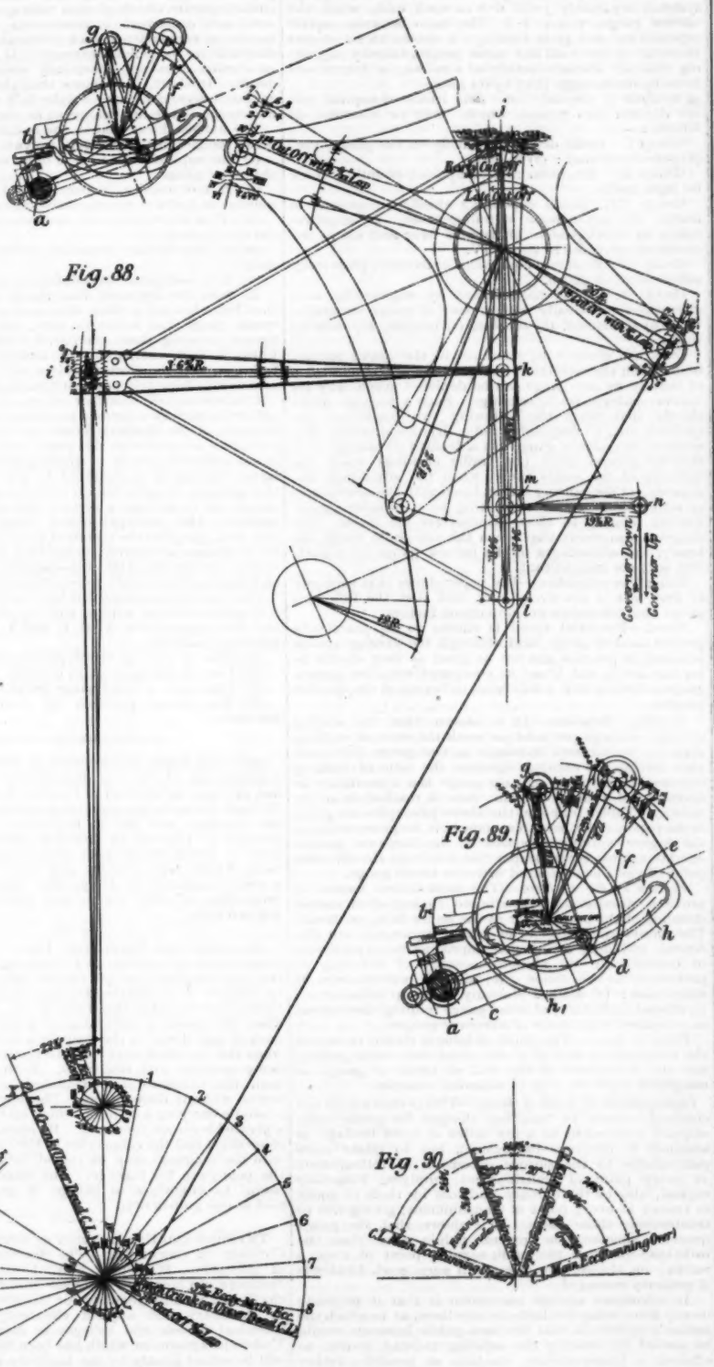
In the trip arrangement illustrated in Fig. 89 the trip hook *a* and the trip lever *b* engage with one another. Both are fitted with hardened steel lips. Attached to the trip hook *a* is an arm *c*, the opposite end of the latter being fitted with a roller *d*, which works in a curved slot of the lever *e*. The latter lever is pivoted on an arm *g* of the operating lever *f*. The slot *e* in which the roller *d* works is laid out on two concentric curves with a common centre at *g*, the two segments being connected by a short curved length, at the point where the roller is shown in Fig. 89. When the roller is working in the part of the slot marked *h*, the trip lever and hook are in engagement, but when in the part of the slot marked h_1 the trip hook is out of engagement with the lever *b*, and the dashpot gear is able to close the valve. The trip hook movement is thus limited to a very small amount. The lever *e* receives its oscillating movement from the auxiliary eccentric through the triangular link *i j k l*. By changing the centre of oscillation *k* a knock off pin, fitted to the lever *e*, is made to arrive sooner or later at the point where the trip is worked, thus giving the necessary variation of cut off. The knock-off pin on the curved lever *e* may be seen in the two views of the trip gear shown in Figs. 75 and 76, Plate XL. Of these, the former shows the gear just at the point of tripping, while the latter shows the link at its extreme position. The arrangement allows the knock-off pin to come to a point exactly opposite the valve stem at the moment required for cut-off, whatever the position of the valve operating lever *f* worked from the wrist plate. The auxiliary eccentric has, as will be seen from Fig. 88, a motion nearly in time with the main crank, and the range of cut-off is practically from zero to full stroke.

As above mentioned, the triangular lever *i j k l* is pivoted at *k*, the pin at this point being carried by the bell crank lever *k m n*. This lever is fulcrummed at *m*, while the end *n* is connected with the governor so that the pivot point *k* is moved under its action. The figures show the movement of the knock-off pin and the point *j* at extreme positions of the governor and the pivot *k*.

Typical details of the bonnet and the dashpot arrangement of these valves are given in Figs. 77 to 84. The arrangement is designed to eliminate all eccentric forces on the valve gear. The bonnet Figs. 77 to 80, extends horizontally from the valve chest, and the dashpot (Fig. 81) is fixed to a flange above it. The trip hook *a*, Fig. 89, is keyed to the horizontal spindle carried by the bonnet at a point where the section A B (Fig. 78) is taken. This spindle is supported on either side of the trip hook. The dashpot is centred above this section. The boss of the main valve operating lever fits as a sleeve over the right-hand end of the bonnet (Fig. 78), and is supported by two wide bearing surfaces. The arrangement permits trips of great width to be employed. The valve spindle is tee-headed, as shown in Fig. 78, and the small detail annexed thereto. It may be pointed out that in trip gears excessive wear usually takes place if they fail to come together fairly when engaging. The gear described has been found to be very free from any tendency to tilt the trips, and gears of the type have been in use since 1902 without the trip steels or the valve gear showing any wear. The photographs reproduced

DETAILS OF COMPOUND WINDING ENGINE.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.



in Figs. 75 and 76 are not of the actual Homestake engine, but of a vertical engine fitted with the same class of gear.

Owing to the Homestake engine having double-ported valves, the angular motion necessary is very small. The actual point at which the valve is tripped is, however, determined by the position of the lever *e*, Fig. 89, and as this has a large angular movement the necessary point can be determined with considerable accuracy. There is further only a reaction on the governor while the roller is passing the short curved path joining the two concentric curves *h* and h_1, Fig. 89, and none while the roller is on the two latter.

The reversal of the winding engine is obtained by varying the position of the eccentrics relative to the crank, in a manner to be described subsequently. In order that the engine may operate equally efficiently in both directions and the cut-off operate through the full range in either, the relative positions of the main and knock-off auxiliary eccentrics must be maintained correctly. Fig. 90 shows the angles through which these eccentrics have to be removed.

It will be noted that the main eccentrics have to be turned through 149 deg. 30 min. for reversing, while the auxiliary has to be swung through 40 deg. The mechanism provided for effecting these movements will be dealt with in our next article.

(To be continued.)

0-10-0-TYPE LOCOMOTIVE FOR RUSSIA.

In 1920 the Nydquist and Holm Aktiebolag, of Trollhattan, obtained an order for 1,000 locomotives for Russia, all of the 0-10-0 type, with tenders, intended for heavy goods service. The contract calls for the delivery of 50 locomotives this year, and 200 next year, and 250 in each of the three subsequent years. In order to comply with these requirements the firm has enlarged its works by shops having a floor area of 172,000 sq. ft., when it is expected the output will be well up to the necessary rate. The firm also has works at Eskilstuna, where tenders and locomotive details are turned out.

The type of engine built for Russia is illustrated in Fig. 1, page 698, the example shown being in the first batch to be tested and despatched. An interesting view taken in the firm's erecting shop is given in Fig. 2, showing engines of this contract in various stages of completion. Compared with English practice the engines present certain unusual features. They are of large dimensions, as will be seen from the table given below. The overall height is just over 17 ft. They are constructed with slab frames which are strongly braced together. Commencing from the leading end the bracing includes the buffer beam, a cast steel box stay between the cylinders and a cast steel open horizontal stay extending between this and the main vertical stay between the first and second axles. Behind the latter vertical stay is an horizontal plate and angle stay extending as far as a cast steel vertical stay between the fourth and fifth axles. On either side of the fifth axle there is a cast steel cross stay, and at the trailing end of the frames a cast steel box stay. At the front end the smoke-box extension of the boiler barrel is carried on a high saddle. At the trailing end the fire-box extends sideways over the frames. A cast steel yoke supports the slide bar and valve rockers, &c., and large cast steel brackets fixed to the frames carry a railed-in running board all round the locomotive. The tenders are carried on two four-wheel bogies, and have a hood matching the engine cab. The chief dimensions are as follow :—

Locomotive :

Gauge	1,524 mm. (5 ft.)
Cylinders, diameter ...	650 mm. (25·59 in.)
Cylinders, stroke	700 mm. (27·56 in.)
Driving wheels, diameter...	1,320 mm. (4 ft. 3·97 in.)
Wheel base driving ...	4,320 mm. (14 ft. 2 in.)
Boiler heating surface ...	207·1 m.² (2,229·2 sq. ft.)
Superheater surface ...	50·93 m.² (548·2 sq. ft.)
Working pressure ...	12 atm. (170·6 lb. per sq. in.)
Grate area	4·46 m.² (48 sq. ft.)
Tractive power	17,500 kg. (38,500 lb.)
Weight in working order...	80·6 tons (metric)
Height above rail level ...	5,212 mm. (17 ft. 1 in.)

Tender :

Coal capacity	6 m³ (212 cub. ft.)
Water capacity	23 m.³ (812·28 cub. ft.)
Weight in working order...	51·6 tons (metric)

Locomotive and Tender ;

Total wheel base	15,822 mm. (52 ft.)
Length overall	20,473 mm. (67 ft. 2 in.)

On account of their size these engines have to be dismantled for shipment by rail through Sweden and Finland. The Swedish gauge is 1,435 mm. (4 ft. 8½ in.). After testing at the works the engines are stripped, the frames and tenders mounted on special wheels, and the boilers transferred to trucks.

THE ROYAL SANITARY INSTITUTE.—The next Congress of the Royal Sanitary Institute will be held at Bournemouth from July 24 to 29, 1922, by invitation of the Mayor and Town Council.

PERSONAL.—Messrs. George Kent, Limited, London and Luton, and J. Blakeborough and Sons, Limited, London and Brighouse, hydraulic and general engineers, have entered into an agreement for merging their organisations.

"WHERE'S WHERE."—This is the title of a new A.B.C. Motor, Marine and Aircraft-Guide to 4,670 places in the United Kingdom, a companion volume to "The Motor, Marine and Aircraft Red Book." It is compiled by Messrs. W. C. Bersey and A. Dorey, and is published at the price of 7*s.* 6*d.* net by the Red Book Publishing Company, Limited, 1, Gough-square, Fleet-street, E.C. 4. It contains 24 town plans. The information, for every place arranged in alphabetical order, comprises the county in which the place is situated, the number of inhabitants, indications as to registration, speed limit, railway serving it, early closing day, hotels, clubs and associations, manufacturers and dealers, branches of insurance offices, garages, &c. Special chapters deal with air navigation data and boat services. The book will prove specially useful to all engaged in traffic by roads, whether for pleasure or for goods delivery, also to private owners of motor cars and motor bicycles.

THE LATE MR. HERMANN SLOOG.

We regret to have to record the death, which occurred on the 4th inst., following upon an operation, of Mr. Hermann Sloog, to whose illness we referred in our article on page 637 *ante* dealing with the meeting of the British Section of the Société des Ingénieurs Civils de France, held on Wednesday, the 2nd inst.

Mr. Sloog was born at Amsterdam in 1884, and after a course at the College Rollin, Paris University, he entered the Paris Ecole Centrale des Arts et Manufactures; his studies there were particularly successful, for on their completion, in 1906, he left the school with the diploma of engineer, having been classed the sixth on the list out of the 200 odd students who were awarded the diploma. He was then for some time engineer to a Paris firm who specialised in the manufacture of metallic filament lamps. He came to London several years ago, and at the time of his death was consulting engineer in London for a number of French electrical companies.

From the foundation of the small but influential association of former students of the Ecole Centrale established in this country, Mr. Sloog acted as hon. secretary to this body; this association subsequently widened its scope, very largely under his influence, and now includes former students of French Universities in general. From it was gradually evolved the well-known "Franco-British Inter-University Group," of which President Poincaré was the guest during his recent stay in London. Mr. Sloog was also a pioneer in the formation of the British Section of the Société des Ingénieurs Civils de France, a section which brings together the numerous members of the parent Institution, who reside in Great Britain and the British Empire. He was the hon. secretary of the section, and, thanks to him, complete success attended the visits paid by the members in June, 1920, to the devastated mining districts of France, and in June last to the metallurgical works of Eastern France. His most earnest desire was always to unite closer together the French and the British professional and intellectual associations, and in furtherance of this he also undertook the onerous duties entailed by the hon. secretaryship of the Board of Control of the British Bureau of the Office National of French Universities. The exchange of engineering students further received his particular attention, and large numbers of those attending the summer courses at Grenoble University will remember his untiring and helpful exertions on their behalf.

Mr. Sloog was a member of the Institution of Electrical Engineers, and was given several years ago a seat on the Council of the Society of Engineers (Inc.). His loss is greatly deplored by a large circle of friends.

THE INDIAN RAILWAY GAUGE PROBLEM.*

By Frederick George Royal-Dawson, M.Inst.C.E.

After seventy years of general railway development in India, the gauge problem still awaits solution, owing to the absence of a definite or consistent gauge policy in the past. The author's object in this paper is to review the position up to date, in order to evolve a suitable course of action. Previous discussions on the subject in the Institution are referred to, the first in 1873, the second in 1889, and the last in 1905–6, *i.e.*, at intervals of sixteen years. The author points out that another sixteen years has now elapsed since the last discussion, and that the present year would therefore be opportune for taking up the question again, especially in view of the new era in Indian administration recently inaugurated under the Reforms Act.

Brief History.—In 1851, when railways were about to be introduced in India, 5 ft. 6 in. was adopted as the standard gauge, in preference to the English 4 ft. 8½ in., as affording greater stability than the latter; and the importance of uniformity of gauge for all Indian railways was insisted on.

In 1863, after about 5,000 miles of railway had been constructed on the standard gauge with English capital on a sterling guarantee of 5 per cent., the Government of India decided that, having regard to the costly nature of the original lines, *bona fide* feeder lines or tramways might be constructed on a narrower gauge as a temporary expedient, to be replaced by standard-gauge lines when justified by traffic development.

In 1869, owing to a demand for an extensive programme of railway construction on a cheap basis, the metre gauge was introduced as a permanent supplement to the standard or broad gauge, on the understanding that the gauges would be confined to definite areas, and that there should be no competition nor overlapping of interests.

In 1880, in view of the expansion of the metre gauge, a committee of railway men recommended that that gauge should be restricted to definite areas, also that feeder lines should be constructed on the same gauge as the parent line, but that anything of the nature of a link connecting with broad-gauge railways should be either constructed on the broad gauge, or so constructed as to be easily converted thereto. These principles have, however, not been adhered to, the result being that at the present time, with a broad gauge mileage of 18,000, and metre-gauge mileage of 15,000, not to mention 3,500 miles of narrower gauges, there is no longer any serious attempt to restrict the gauges to particular areas or spheres of influence.

Facts and Figures.—The paper points out that while the railways of India, treated as one system, yield a net return of 6·8 per cent., the broad and metre-gauge systems separately yield 6·9 in each case, while the narrow gauges return 3·3. The ratio between capital expenditure and gross earnings is shown to be almost identical on the broad and metre gauges, thereby suggesting that the ultimate outlay on a railway is determined more by its earnings than by its gauge.

Analysis of Capital Cost.—The items of capital cost are divided into groups, which may be classified as follows:—

Group I. Items depending chiefly on the gauge, viz., (*a*) permanent way; (*b*) ballast.

Group II. Minimum first equipment of rolling stock for light traffic.

Group III. Items depending chiefly on growth of traffic, viz., (*a*) increase of rolling stock; (*b*) improvements or developments of fixtures over and above the minimum provided in Group IV.

Group IV. Minimum equipment of fixtures, practically independent of gauge.

Group V. Items necessitated by engineering considerations practically independent of gauge or traffic, viz., (*a*) formation, (*b*) tunnels, (*c*) bridges, (*d*) training works.

Data are given with reference to the above groups, from which the estimated cost per mile of a single track of railway on any gauge can be depicted graphically for various scales of traffic earnings. Such a diagram shows clearly that when the following two conditions are fulfilled, viz., (i) very light traffic, (ii) exceptionally easy country, the narrow gauge has a decided advantage over broader gauges until the traffic earnings reach the capacity of the single track, when the advantage disappears, for the railway is then faced with the alternative of either doubling or converting to a broader gauge. Figures relating to these alternatives are given. The diagram also shows that when the sub-grade works are heavy, the advantages of the narrow gauge as regards first cost are insignificant.

Gauge Characteristics.—The paper shows that economy of first cost is not everything, and that the following gauge characteristics are important factors.

Speed.—Potential speed is shown to be practically proportional to gauge, and although the average speeds attained in practice are not as great as they should be for the metre and broad as compared with the narrow gauges, there is still a difference in favour of the broader gauges.

Working Expenses.—It is shown that for similar average earnings per mile per week the ratio of working expenses to earnings increases as the gauge decreases, also that as the earnings increase the ratio of working expenses to earnings on any gauge has a tendency to decrease till a fairly constant ratio is reached on every railway. Tables based on the above principles are given in the paper, and other tables show how, for given earnings the higher working expenses of the narrower gauges operate against their cheaper first cost from the dividend point of view, as compared with the broad gauge.

Factors of the Problem.—The inconclusive nature of previous discussions is attributed to imperfect understanding of the problem, or to the issues being confused. The merits and demerits of former arguments are discussed, including (*a*) alleged unproductive expenditure of conversion; (*b*) alleged economy of doubling in preference to conversion; (*c*) alleged inconvenience of conversion; (*d*) alleged economy of cheap initial cost; (*e*) alleged inefficiency of broad gauge running dimensions as compared with those of narrower gauges.

Point at Issue.—The point at issue is shown to be, not the comparative merits of the broad and metre gauges, but the magnitude of the evil of break of gauge as compared with the cost of remedial measures.

Inconvenience of Break of Gauge.—This is shown to be not confined merely to handling charges for goods transhipped (equivalent to a few miles of extra haulage as assumed in previous discussions), but to relate more particularly to the serious detention of rolling-stock at every point of transhipment, implying locked-up capital, also to the damage and loss by theft of goods in transit at every point of transhipment, giving rise to troublesome claim cases. It is shown that the gauge question concerns the general public more than the railways, for from the profit-earning point of view a railway on almost any gauge will earn good dividends if properly managed.

An argument against conversion is that it prevents money from being available for new lines, as to which the author's opinion is that the best public interests would be served by making the existing railway system as efficient a transportation machine as possible, rather than by making a fetish of mere mileage progress.

Another argument against the elimination of the metre gauge is that the effect of such elimination would be to stimulate the growth of 2-ft. 6-in. and 2-ft. gauge lines, and that narrow-gauge lines would thus form the nucleus of a system which might in a few years be as difficult to deal with as the metre gauge. The author's reply to this is that the narrow gauges have their own limitations as regards capacity and speed, and that consequently they will never rival the broad gauge, the tendency being to convert to the latter as soon as traffic conditions justify such conversion.

The diagram given in the paper, however, shows that there is a distinct field of usefulness for cheap narrow-gauge lines in easy country when the traffic prospects are uncertain, and that such lines would supplement broad-gauge lines until the earnings justified conversion thereto. In such circumstances the use of an intermediate or metre gauge is superfluous.

Lastly, an argument against conversion is that existing working contracts prevent drastic action. To which the author replies that, as working contracts are framed by the Government of India, and are terminable at specified periods, also that as the Government has the largest share in the dividends of most railways, existing contracts need not constitute a permanent or insurmountable barrier to conversion if such conversion were considered desirable in the public interests. It is also shown that conversion does not necessarily connote reduced dividends. In short, it is shown that the above arguments against conversion carry weight only with those who do not recognise the dual gauge as an unmitigated evil.

The author shows that in the battle of the gauges the broad gauge must ultimately prevail, because:—

(i) The capital sunk in it is more than double that of the metre gauge.

(ii) It now carries 80 per cent. of the total railway tonnage of India at remunerative rates.

(iii) It is inherently more economical in working than the metre gauge.

(iv) It has higher potential speeds than the metre gauge.

(v) It is susceptible of indefinite expansion.

To meet the argument that things have gone too far, that India has not a clean slate to start on, and that the metre gauge has come to stay, the author adduces figures showing that, compared with other countries, India is still comparatively undeveloped as regards railways, and therefore that it is not too late to devise means for ultimately eradicating the dual gauge.

Conclusions.—The author refers to the outlines of a policy framed by a former president and a former chief engineer of the Railway Board, in accordance with the principles advocated in this paper, and points out that it is not sufficient merely to frame a policy, but that legislative machinery is required to put it in force. For this purpose, he proposes an enlargement of the Railway Act so as to include a section dealing with the gauge question, the principal object being to establish the 5-ft. 6-in. gauge as the standard gauge of Indian railways. Draft clauses are given, embodying that idea, and providing for dealing with non-standard railways, present and future, with a view to securing ultimate uniformity.

The paper is accompanied by a railway map of India, a diagram showing capital cost in relation to earnings, and four appendices, A, B, C and D, dealing with the following matters:—

(A) List of railway developments since 1905.
(B) Cost of rolling-stock in relation to earnings.
(C) Examples of local gauge problems.
(D) The gauge problem in Australia and South America.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, November 15, 1921.

Iron and Steel Production in October.—Although a settlement of the coal dispute was arrived at at the end of June, by the end of October there were still only 82 blast furnaces in operation compared with 109 before the stoppage and 300 in September, 1920. The production of pig-iron in October amounted to 235,500 tons, of which 80,200 tons were hematite, 63,300 tons basic, 74,500 tons foundry and 13,600 tons forge, with a small quantity of alloys and other qualities; the production of steel ingots and castings amounted to 405,400 tons.

Magneto and Insulated Plug Tester.—A very simple form of instrument for testing the magneto and the plug insulation of gas engines has been brought out by Messrs. E. J. Davis and Co., of Rapidising Works, Great Eastern-road, Stratford, E. 15. Not infrequently when the sparking apparatus of a gas engine fails, the fault is put down to the magneto, and it is dismantled when the trouble is really due to the insulated pole-piece being earthed, and *vice versa*. With the Davis tester both the magneto and insulated pole-piece may be tested without dismantling. The appliance consists of a handle carrying a stem on which an insulated plug and a pivoted lever are mounted. By means of an earth wire connection and the connection of the insulated pole-piece wire the magneto may be tested for sparking and also the pole-piece for leakage. The tester should be very useful to engineers in charge of gas engines. It is sold at one guinea net.

Training and Examination of Students following Courses in Chemistry.—The Secretary of the Board of Education, Whitehall, S.W. 1, announces that the Institute of Chemistry has consented to co-operate with the Board in arrangements for the award of certificates in chemistry and applied chemistry to students in technical schools and colleges in England and Wales. Under the agreement which has been reached, certificates will be issued jointly by the Institute and the Board on the successful completion of approved courses. The scheme will provide both for full-time students and for part-time students. Detailed arrangements for the administration of the scheme will be given in rules which are now in course of preparation and will be published shortly. The Board understands that the Institute will consider at a later date whether and how far the training and the higher certificates may qualify for admission to the examination for the diploma of associateship of the Institute. Should the authorities of any school in England desire further information, their inquiries should be addressed, pending the issue of the rules, to the Expert Inspector to whom the chemistry courses of the school are assigned for inspection. Inquiries from the authorities of schools in Wales should be addressed to the Permanent Secretary, Welsh Department, Board of Education, Whitehall, London, S.W.1.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Many of the big engineering concerns in South Yorkshire are being run at a loss to keep their commercial organisations together in readiness for more prosperous conditions. The latest cut applies to the salaries of departmental managers in rolling mills, forges and press shops, who within the ensuing month are to sacrifice 10 per cent. In face of this, however, there is a growing feeling of hopefulness. The stabilisation of quotations for raw and semi-finished materials is apparently well in sight. It is doubtful, in the opinion of producers, whether any further reduction will be made in steel rates. Consumers can now place orders at prices comparable to those quoted on the Continent, and, moreover, have the advantage of dealing in goods of guaranteed quality. At the moment inquiries are decidedly more numerous, but buying is still of a hand-to-mouth character. Lower rates are anticipated in fuel costs locally, and there is a strong movement among manufacturers' organisations to press for further concessions from railway companies in the carriage of ore and other essentially basic materials. Wagon departments are busy on repairs. New business in rails and axles is largely confined to India and the Argentine. The production of textile machinery for export, and machine tools both for home and foreign use, is on a much wider scale than the output in any other section of the machinery trades. Exceptional competition has sprung up between local concerns producing files, saws, pincers and other hand tools and implement parts. Rates have been severely pruned to meet the requirements of potential customers, who are prepared to place substantial orders, but only on their own terms. Rolling-mill costs are the subject of wide complaint among file manufacturers.

South Yorkshire Coal Trade.—The keen competition displayed for new business in house coal has resulted in a general weakening of values. Best qualities of domestic fuel, which for a considerable time have been maintained at maximum prices, have eased 2*s.* to 2*s.* 6*d.* per ton, compared with a week ago. Collieries are doing their utmost to attract orders, and in some cases are offering unscreened house coal delivered within a radius of 6 miles to 8 miles at the exceptionally low figure of 27*s.* 6*d.* per ton. A renewed accumulation of slacks has induced collieries to make an all-round reduction of 1*s.* per ton to keep pit-heads and sidings free from congestion. Export business in steam hards, *via* the Humber, is being done as low as 19*s.* per ton. Cobbles, nuts and coke constitute a very quiet market. Quotations :—Best branch handpicked, 39*s.* to 40*s.*; Barnsley best Silkstone, 38*s.* to 40*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 29*s.*; Yorkshire hards, 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 15*s.* to 16*s.*; smalls, 5*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues small. The very restricted production of the better qualities is apparently quite sufficient for current needs, and supply of the inferior grades is abundant. Under such circumstances values naturally tend downward, and it is understood that second hands would readily shade makers present quotations to obtain orders for delivery a little way ahead. Buyers report very prompt dispatch of the few orders they are able to give out. To home customers No. 1 is 115*s.*, and No. 3 G.M.B. is 110*s.*, the export price of these qualities being 5*s.* above home rates. The lower grades are on sale either for home use or for despatch to foreign destinations at 105*s.* for No. 4 foundry, 100*s.* for No. 4 forge and mottled, and 97*s.* 6*d.* for white iron.

Foreign Ore.—There is next to nothing doing in foreign ore, consumers, in addition to having heavy stocks, having still large supplies to take in fulfilment of old contracts. Prices are based nominally on 27*s.* c.i.f. for best rubio, but doubtless offers on lower terms would receive consideration.

Coke.—Coke prices are still too high to meet the views of local consumers, nearly all of whom show very marked disinclination to pay 30*s.* for Durham blast-furnace average sorts, which is the lowest figure asked. Low phosphorus descriptions are quoted 32*s.* 6*d.* Both quotations are for delivery at consumers' works.

Manufactured Iron and Steel.—Very little new is ascertainable concerning the various branches of the finished iron and steel industries. Sales are still difficult to arrange, and what business is passing continues of the hand-to-mouth kind. Among the principal market quotations are :—Common iron bars, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fish-plates, 15*l.* 10*s.*; black sheets, 15*l.* 10*s.*; corrugated galvanised sheets, 18*l.* 10*s.*; steel billets (hard), 9*l.* 10*s.*; steel billets (medium), 9*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal as cargo from South Wales to foreign ports, in the past week totalled 486,000 tons, which established a record for any week in this or last year, and was double the quantity despatched in the corresponding week of 1920, and only 8 per cent. below the total for the corresponding week of 1913. That the volume of exports have substantially increased since the termination of the national strike proves that the present depression in the Welsh coal trade is chiefly due to a reduced inland demand. Shipments from Cardiff in the past week amounted to 300,000 tons, from Newport 80,000 tons, from Swansea 71,000 tons, from Port Talbot 21,000 tons, and from Llanelly 13,000 tons. While exports have expanded coal prices have fallen, and in October there was a further drop in the average values. Large steams shipped from Cardiff averaged 32*s.* 8*d.* per ton f.o.b. in October, compared with 36*s.* 4*d.* in September, and 74*s.* 11*d.* in January; steam smalls 16*s.* 8*d.* against 16*s.* 10*d.* and 48*s.* 7*d.*, respectively. The price of anthracite coals have, however, been maintained for the October average for large, shipped from Swansea, worked out at 55*s.* 6*d.* against 54*s.* 8*d.* in September, and 82*s.* 7*d.* in January, and for smalls 39*s.* 5*d.*, against 35*s.* 11*d.* and 55*s.* 2*d.*, respectively. On the open market, prices for large steams continue to decline, and supplies are ample to meet buyers' requirements. Best Admiralty large is freely available at 25*s.* 6*d.*, and second at 25*s.*, with Monmouthshire large from 23*s.* to 25*s.* Smalls, however, are scarce, with prices dependent on the quantity large buyers are prepared to take. For small alone, sellers demand a premium of 1*s.* to 1*s.* 6*d.* per ton on the price accepted, and stipulate a proportion of large being taken. As illustrating the scarcity of smalls, it is stated that buyers have purchased two-thirds large and one-third small at a through price of 21*s.* to 23*s.*, and that in the actual shipment all large has been supplied, the collieries being unable to spare small.

Iron and Steel Trade.—There is a better inquiry for Welsh tin-plates, and the general opinion of manufacturers is that the outlook is more promising than it has been for some time past. Inquiries are circulating from Holland, Roumania, Argentine, and the Near and Far East, while it is reported that a large order for British Columbia has been secured in competition with American makers. About two-thirds of the mills are running, and prices are steady at 22*s.* 6*d.* f.o.b. for prompt delivery and 21*s.* for the first quarter of next year. Sheet and tin bars are unchanged at 7*l.* 15*s.* per ton delivered, while Belgian bars are from 8*l.* 5*s.* to 8*l.* 10*s.* and German bars 8*l.* to 8*l.* 5*s.* per ton.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The past week has been one of no little moment to those connected with the steel industry, and the severe competition of years past looks very much like returning. A meeting took place in London last week between the Scottish and English steel makers' associations, and following hard on that we find that the old territorial arrangements have now fallen through and that each can seek business in the other's districts. Already firms in the south are offering various kinds of material for delivery in the Clyde area at the same rates as these are quoted to their own local customers. As these prices are about 2*l.* per ton under those named by the local producers here last week the market has become rather unsettled. The decision arrived at by the Scottish makers was to "free" ship plates and angles, and while the English firms are naming 10*l.* 10*s.* per ton delivered Clyde for ship plates, and 10*l.* per ton for angles, the home producers have not gone as low as these prices for plates yet, and have named 11*l.* per ton for them, and 10*l.* per ton for angles. Interesting developments are now likely to follow. In the meantime there has been little change in the position and any important buyers who were about to enter the market are not now very anxious to give out contracts just at the moment, because of the possibility of even more favourable terms by a little longer delay. Inquiries have increased considerably and more activity is likely to reign in the various works in the near future, but the one fly in the ointment is the cost of production, and unless that is very largely reduced soon the bulk of the business will be unremunerative. The following may be taken as the current prices, but owing to competition a favourable specification may receive slightly more generous terms :—Boiler plates, 15*l.* per ton; ship plates, 11*l.* per ton; and sections, 10*l.* per ton, all delivered Glasgow.

Black Steel Sheet Trade.—Business in black sheets has not been over plentiful of late and most works have been going very slowly. Foreign inquiries have been fair, and while a moderate amount of dealing has taken place there has been little life in it. Prices all round have been coming down in order to induce buying, and the Scottish Black Sheet Makers' Association decided to cut their home area prices by 20*s.* per ton, and the basis price for ¼-in. sheets is now 12*l.* 15*s.* per ton, net, delivered Glasgow or equal.

Malleable Iron Trade.—No change can be reported in connection with the West of Scotland malleable iron trade, and hand-to-mouth conditions are all too general. Fresh orders are exceedingly difficult to secure, but makers are hopeful of things improving before long. The price quoted for "crown" bars is still 14*l.* per ton delivered Glasgow.

Scottish Pig-Iron Trade.—The state of the pig-iron trade of Scotland is still very depressed and movement is very slow indeed. Prices are all weaker and, owing to the falling market, home buyers are acting with great caution, and bookings do not amount to a heavy tonnage. To-day's quotations are :—Foundry iron No. 1, 6*l.* 15*s.* per ton, and No. 3, 6*l.* 10*s.* per ton, both at makers' works; hematite iron, 6*l.* 15*s.* per ton, delivered at the steel works.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 18, at 6 p.m., at Storey's Gate, St. James's Park, S.W. 1. A paper by Mr. E. H. Salmon, D.Sc., on "The Machinery of Floating Docks," will be read and discussed.

THE INSTITUTION OF GAS ENGINEERS.—Friday, November 18, at 11 a.m., at the Public Works, Roads and Transport Congress, Royal Agricultural Hall, Islington. Papers by : (*a*) "Public Lighting by Gas," by Dr. J. S. G. Thomas and Mr. Dean Chandler; (*b*) "The Utility of Benzole for Transport Purposes," by Captain E. de Normanville. At 2.30 p.m. Papers by : (*c*) "Tar for Public Roads," by Mr. Hugh James; (*d*) "The Reduction of Atmospheric Pollution resulting from the Use of Gaseous Fuel," by Mr. J. S. Owens, M.D.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, November 19, at 7 p.m., at the Education Offices, St. James'-road, Dudley. Paper by Mr. L. G. Harris, of Messrs. Guest, Keen and Nettlefolds, on "British and Belgian Methods of Guide Rolling and General Forge Practice."

THE INSTITUTION OF MECHANICAL ENGINEERS : GRADUATES' MEETING.—Monday, November 21, at 7 p.m., "Some Thoughts on Motor-Cycle Engine Design," by Mr. John Harrison, Graduate, of London. Chairman : Lieutenant-Colonel A. E. Davidson, D.S.O., R.E., Member of Council.

THE WOMEN'S ENGINEERING SOCIETY.—Tuesday, November 22, at 6.15 p.m., at 26, George-street, W. 1. Lecturer, Miss Mary Abbott; subject, "Women and the Conquest of the Air" (illustrated with lantern slides). Chair, The Hon. Lady Shelley-Rolls.

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 23, at 8 p.m. : "Trueman Wood" Lecture, "The Coming of Age of Long-Distance Wireless Telegraphy and Some of its Scientific Problems," by Professor John Ambrose Fleming, M.A. D.Sc., F.R.S., Albert Medallist. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside. Friday, November 25, at 4 p.m. : Dominions and Colonies and Indian Sections (Joint Meeting), "An Imperial Airship Service," by Mr. A. H. Ashbolt, Agent-General for Tasmania. Brigadier-General Lord Montagu of Beaulieu, K.C.I.E., C.S.I., will preside.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, November 24, at 7.15 p.m., at Caxton Hall, Westminster, a paper will be read on "Axleboxes and Hornblocks," by Mr. A. E. Kyffin.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (SCOTTISH CENTRE).—Friday, November 25, at 7.30 p.m., in the Societies' Room, Royal Technical College, Glasgow, a paper will be read entitled "The Locomotive from a Footplate Point of View," by Mr. J. P. Grassick.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 25, at 8 p.m., at Caxton Hall, "Electro-Magnetic Instruments—Problems in Design and Construction," by Mr. G. F. Shotter (Member). Exhibits and demonstrations. Saturday, November 26, at 2.30 p.m., visit to the Locomotive Sheds of the Great Western Railway at Old Oak Common.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, November 25, at the Institution of Mechanical Engineers, Storey's Gate, London, S.W., at 7.30 p.m., Mr. A. F. Guyler (member), of Nottingham, will deliver a paper dealing with "Drawings and Production," to be illustrated by lantern slides.

LOW-TEMPERATURE CARBONISATION.—We recently published a detailed description of the works of Messrs. Low-Temperature Carbonisation, Limited, near Barnsley, where slack coal is converted into a smokeless fuel and the valuable by-products recovered. It is therefore interesting to note that Mr. Harald Nielsen, a Danish engineer, is working at the same problem and has constructed an experimental plant at Chatterley, in North Staffordshire. According to a brief description given in *The Times Trade Supplement* of November 12, it appears that Mr. Nielsen's plant comprises a large rotary retort heated by producer gas and capable of continuous operation. A very high overall efficiency is claimed for the process, and the coal is said to be effectively carbonised and stripped of its smoke-forming constituents in its passage through the retort, which occupies only 2½ hours.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Having in view his long association with electrical progress in this country, and his great services to the Institution in connection with the obtaining of a Royal Charter and Royal patronage, when his enthusiastic help, by counsel, advice and active co-operation with the Charter Committee proved invaluable, the Council of the Institution of Electrical Engineers have elected as an honorary member Lord Southborough, P.C., G.C.M.G., &c. Lord Southborough is better known to electrical men under his older title of Sir Francis Hopwood. He has had a distinguished career in the Board of Trade and other Government Departments, and in the 'eighties was closely associated as Assistant Solicitor to the Board of Trade with electrical legislation. He is on the Board of Control of the National Physical Laboratory, where he has actively supported research and experimental investigation of electrical matters.

0-10-0-TYPE LOCOMOTIVES FOR RUSSIA.

CONSTRUCTED BY THE NYDQUIST AND HOLM AKTIEBOLAG, ENGINEERS, TROLLHATTAN.

(*For Description, see Page* 695.)

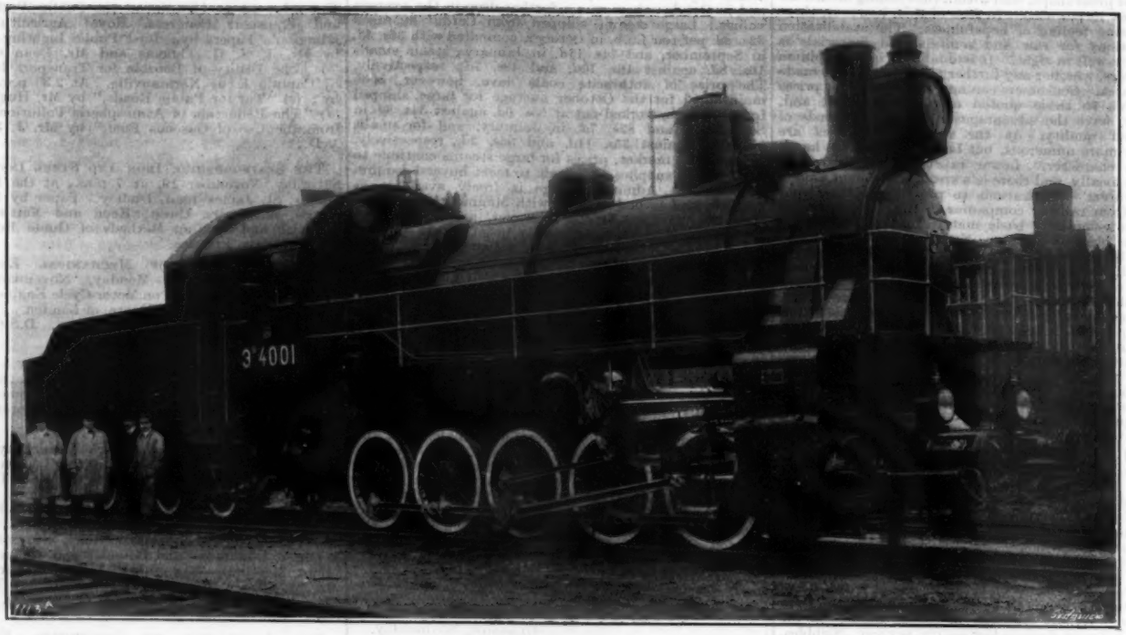


FIG. 1. GENERAL VIEW OF ONE OF THE LOCOMOTIVES.

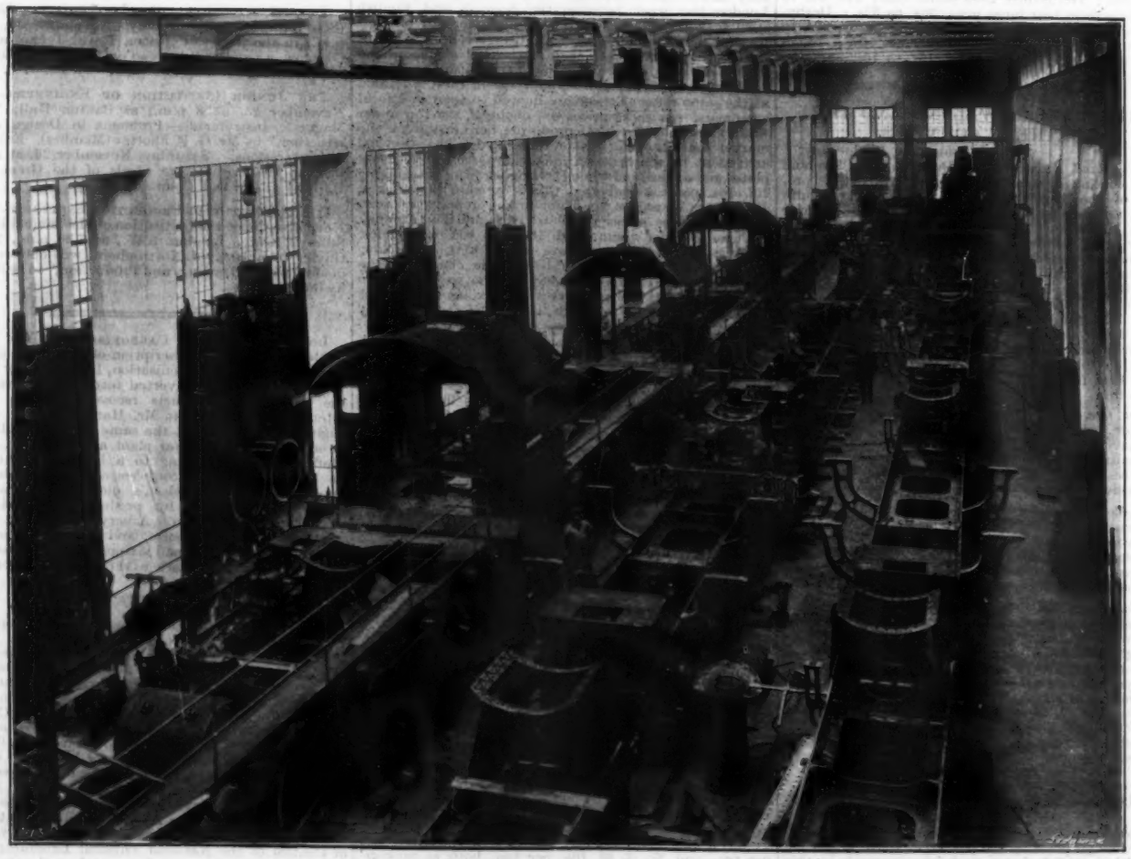


FIG. 2. VIEW IN ERECTING SHOP; LOCOMOTIVES FOR RUSSIA UNDER CONSTRUCTION.

DETAILS OF COMPOUND WINDING ENGINE FOR THE HOMESTAKE MINING COMPANY.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.

(For Description, see Page 694.)

Fig. 57.

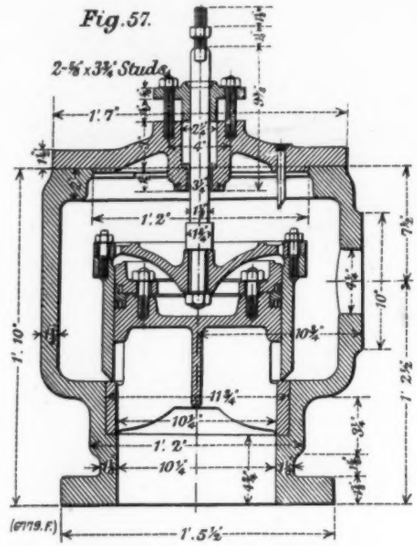


Fig. 58.

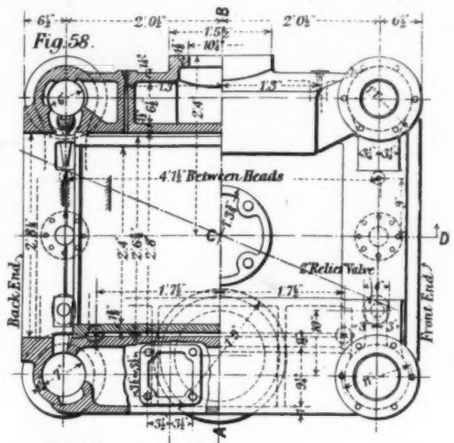


Fig. 59.

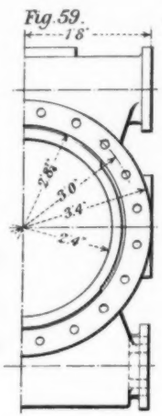


Fig. 60.

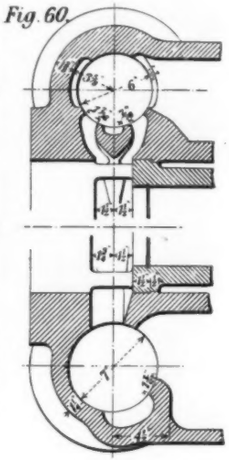


Fig. 61.

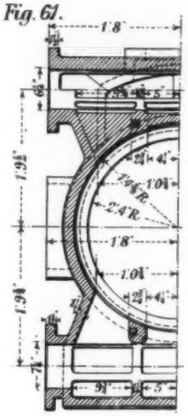
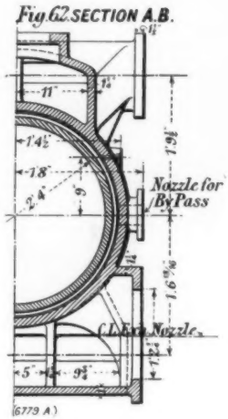


Fig. 62. SECTION A.B.



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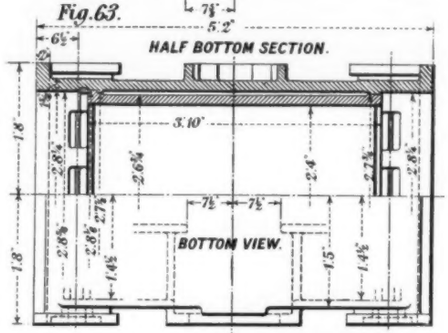

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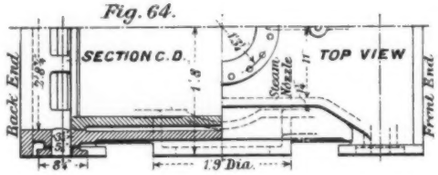


Fig. 65.

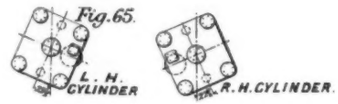


Fig. 66.

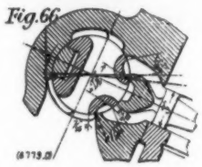


Fig. 67.

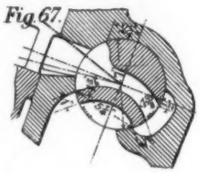


Fig. 68.

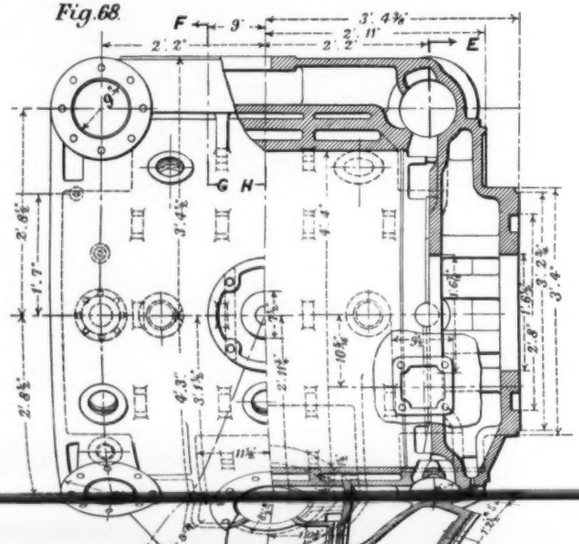


Fig. 69. HALF END VIEW. HALF SECTION E.E.

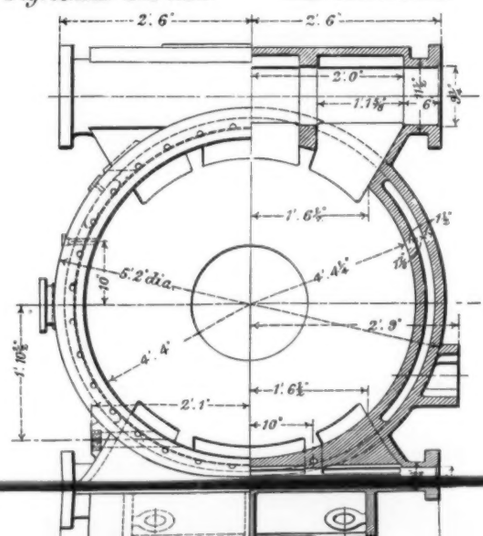


Fig. 70. HALF SEC. F.G.H.I.

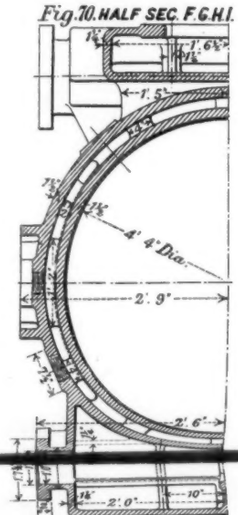
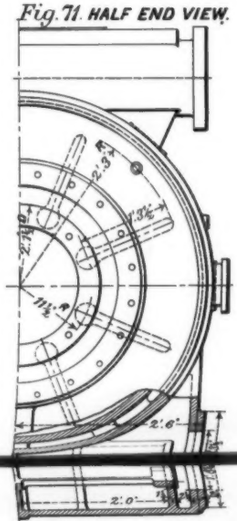


Fig. 71. HALF END VIEW.



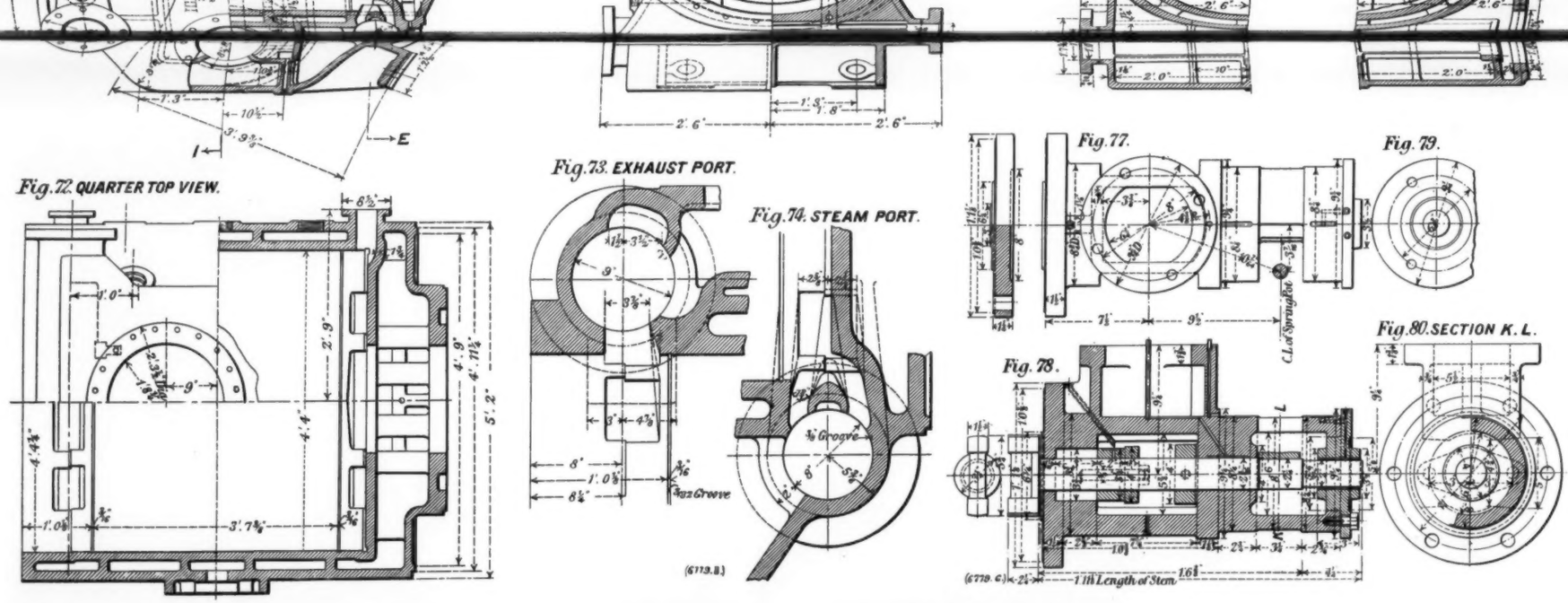


Fig. 72. QUARTER TOP VIEW.
Fig. 73. EXHAUST PORT.
Fig. 74. STEAM PORT.
Fig. 77.
Fig. 79.
Fig. 78.
Fig. 80. SECTION K. L.
Fig. 81.
Fig. 82.
Fig. 83.
Fig. 84.
E
I
L
K
⅛ Groove
3/32 Groove
Length of Stem

FIG. 75.

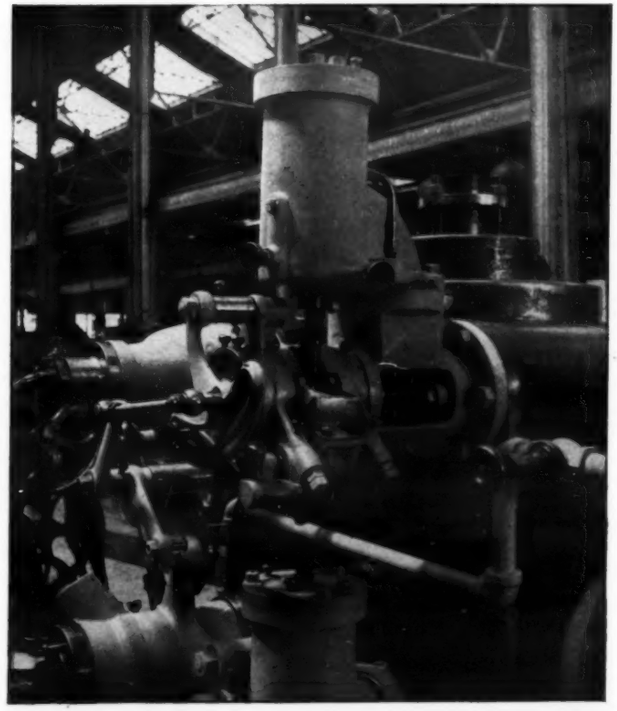


FIG. 76.

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AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Ltd., 87, Queen Street East.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
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GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink, and Co., Bombay; Thacker and Co., Limited.
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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for Advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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ENGINEERING.

FRIDAY, NOVEMBER 18, 1921.

STRIKES AND UNEMPLOYMENT BENEFIT.

At a time when large sums are being provided by Government for the relief of the unemployed, it is not unimportant to consider the attitude which is adopted towards those who are unemployed in consequence of trade disputes. That the mere striker does not himself receive out-of-work benefit is by this time fairly well known; and it is obvious that it must be so. If everyone who struck was entitled to be paid by the State, the entire industry of the country might be suspended while the former workers lived at the expense of the National Insurance Fund. That fund would not long stand the strain. Again, it is probably common knowledge that men locked out *en masse* are not entitled to benefit. If they were, there would be a greater tendency for them to refuse terms which might in other circumstances be reasonable. But while the Unemployment Insurance Act is fairly simple in its application to strikers and men locked out, its meaning in relation to men indirectly affected by a strike is not so easy to comprehend. Nor is it easy for an employer, or anyone else for that matter, to procure accurate information on the subject. This is partly due to the fact that the general public knows but little of the way in which unemployment benefit is administered. They hear something, but nothing very definite of "Courts of Referees," but they know little about these tribunals or their decisions. This is due to the fact that unlike other courts the Court of Referees is held in private. Indeed, it is not too much to say that the disrepute into which the whole administration of unemployment benefit has fallen is largely due to this system of private administration.

The critics are generally ignorant of the fact that each claim for benefit is submitted to the careful consideration of an impartial tribunal. But it is undoubtedly important that employers should be acquainted with the effect of a strike or a lock-out upon the payment of out-of-work benefit, as it may very considerably affect the policy which they shall adopt. It is for this reason that it is proposed to indicate some of the points which have been authoritatively decided in relation, more particularly, to the right of those indirectly affected by a trade dispute to make a claim for benefit. It is conceived that a little accurate knowledge on this subject may be of use to the employer who is not quite sure how the strike or the lock-out will affect claims to out-of-work benefit which may be made by persons indirectly affected.

And first as to the provisions of the Act itself. It is provided by Section 8 (1) of the Act of 1920 that "an insured contributor who has lost employment by reason of a stoppage of work which was due to a trade dispute at the factory, workshop or other premises at which he was employed shall be disqualified for receiving unemployment benefit so long as the stoppage of work continues, except in a case where he has, during the stoppage of work, become *bona fide* employed elsewhere in the occupation which he usually follows or has become regularly engaged in some other occupation. Where separate branches of work which are commonly carried on as separate businesses in separate premises are in any case carried on in separate departments on the same premises, each of those departments shall for the purposes of this provision, be deemed to be a separate factory or workshop or separate premises as the case may be." Certain points are reasonably clear from a perusal of the section itself. In the first place if work is stopped at a factory because the supply of raw material has failed owing to a strike elsewhere, the men at the factory will not be disqualified. In the second place, there must be a stoppage of work. Suppose that out of ten fitters employed in a shop, four left work because of a dispute over wages, or some alteration in the hours of labour or conditions of employment, they would not necessarily be disentitled to claim benefit because of a dispute over wages or some alteration in the hours of labour or conditions of employment, nor would they be necessarily disentitled to claim benefit because of a trade dispute.

The object of the proviso to the section may be thus explained. Suppose there is a factory divided up into several departments—the first of which furnishes raw material, so to speak, for the second, and so on. If a trade dispute causes the first department to be closed down, with the result that the men employed in the second are necessarily dismissed, having no work to do, they will be persons affected by a trade dispute, and as such will not be able to claim benefit. It follows that a dispute directly affecting a comparatively small number of men may not only deprive others of employment but of unemployment benefit as well. The object of the proviso to the section is to lessen the hardship which may result from this, the necessary consequences of the first part of the section. Suppose, for example, a trade dispute took place in a motor works where "chassis" were made in one department and "bodies" in another. A strike of chassis builders might ultimately cause the "body" department to be closed. In such a case the "body" builders could not claim benefit unless it were proved that the building of bodies was ordinarily carried on as a separate business.

An examination of these various points will suggest to the careful reader others which are by no means easy to decide. Where a claim to benefit is disputed, it falls to be determined by a Court of Referees. From the Court of Referees an appeal lies to the umpire whose reasoned decisions are from time to time published by the Ministry of Labour. It is now proposed to quote a few of these decisions in which some questions of general importance have been discussed. It should be mentioned that the facts in each case have been ascertained by a Court of Referees—a tribunal which consists of an employers' representative, a workman's representative and an impartial chairman, usually a barrister-at-law, appointed by the Minister of Labour.

The question what constitutes "a separate department" where men are employed on building operations arose in one case in these circumstances. The employers were engaged on building large offices. They had two "departments," *e.g.*, the electric department and building department. The electricians, whose duty it was to attend to power for the cranes and mortar machines, came out on strike, with the result that all machinery was stopped. Amongst others, a carpenter's labourer, who was employed in the building department, having been discharged, claimed unemployment benefit. It was contended that wiring and maintenance work performed by electricians was carried on in a "separate department," and that it was commonly carried on as a separate business in separate premises from building. The umpire, however, held that he could not regard the applicant as being employed in a "department" separate from that of the electricians and disallowed the claim.

In another case the applicant, who had been employed as check weighman at a colliery, lost his employment owing to a strike of coal miners at the colliery at which he had been employed. He was not employed by the colliery owners, but by the miners, and was in no way connected with the dispute. He admitted, however, that he lost his employment solely because the miners had ceased work. In these circumstances a claim for benefit was disallowed. The umpire said: "This applicant lost his employment as a result of a stoppage of work due to the miner's dispute. The work of a check weighman must necessarily be carried on at the colliery premises, and cannot be commonly carried on as a separate business in separate premises from mining."

The Unemployment Insurance Act provides that a man shall not be obliged to accept employment in a situation vacant in consequence of the stoppage of work due to a trade dispute. In other words, a man refusing such work shall not be deemed to have refused suitable employment—that being one of the

disqualifications for benefit—were he asked to work as what is commonly termed a blackleg. In one case the applicants had been employed as fitters and turners in the engineering shop at a metal works, but they were discharged for refusing to do the work of their labourers who were in strike. This refusal was based on the ground that they were justified in refusing to infringe on the work of other men who were in dispute with the firm. The umpire, however, refused to allow benefit. He said: "It was the absence of the labourers in connection with the trade dispute which made it impracticable for the applicants to carry on their work, and that constitutes a stoppage of work which was due to a trade dispute." Where a man was absent from his work through illness and then came back to find that owing to a trade dispute which had begun since he became ill, the works were closed, he was held not entitled to benefit. In such a case the trade dispute must be regarded as the cause of his losing his employment.

Another case shows that the expression "trade dispute" may be interpreted to mean something very much like "trade union tyranny." A man who claimed benefit had been thrown out of work in these circumstances. He was in arrears with his contributions to his association. As he was unable to pay them all at once the secretary took steps to obtain his discharge. The employer was informed that there would be a strike of the masons employed by him unless the applicant was discharged forthwith, and in order to prevent the threatened stoppage of work the employer dismissed the applicant. In these circumstances it was held that the applicant did not lose his employment owing to a trade dispute, as he had no difference whatever with his employer who merely discharged him in order to prevent unpleasantness with the other workmen.

It is enough that the stoppage has occurred owing to a threat of a strike. In one case certain pattern makers who had a dispute with their employers, gave notice of their intention to strike. The employers, anticipating a shortage of work in view of the strike, which they knew would take place in a day or two, discharged the applicant who was a pattern maker. The pattern makers went on strike on the following day. It was held that in these circumstances the workman had lost his employment owing to a stoppage of work due to a trade dispute.

THE FLOW OF METAL DURING FORGING.

Anyone who has examined the appearance of an article stamped or pressed from a sheet, the original surface of which was marked with rectangular lines, must have been struck by the nature of the distortion the metal has undergone. The lines are found to have become crowded together in some places and widely separated in others, thus demonstrating a surface flow of the metal which must have involved the solid metal in the interior in its movement. When the working has been very severe, as in the manufacture of a rifle cartridge case from a plain brass disc, it is evident that certain portions of the metal must have travelled long distances from their original position. The new surface being many times greater than that of the disc, shows that internal particles must have assumed an external position and indicates a profound distortion and reconstitution of the internal structure. Changes of this nature must take place when ever metal in a plastic state is caused to alter its form, whether by hammering, bending, drawing or forging, and the ultimate strength of the finished product is bound to be affected by such changes in so far as their effect is not neutralised by subsequent treatment of the metal.

The nature of the internal movements which occur when metal is forged was studied more than forty years ago by M. Tresca, who extruded a cylinder formed of a number of lead discs packed together and examined sections of the extruded metal. The original surfaces of the discs could be recognised in the finished work, and their relative distances apart at various points gave a measure of the flow that had taken place in the metal between them. Subsequent experimenters have worked with billets composed of alternate layers of differently-coloured wax or "plasticine" which have the advantages of homogeneity and of being deformable with comparatively low forces. By the use of such billets it is easy to investigate the nature of the flow of metal when deformed in any way, and during the war the flow of steel under the action of a shell, forging press was noted by the same method. The object of such investigations is usually to find out the direction of the grain in various parts of the finished forging, as this feature is correlated with the strength of the parts to resist particular stresses. How important this correlation may be was shown by Mr. Harry Brearly, who pointed out in a paper before the Association of Drop Forgers and Stampers, in 1918, that the strength of teeth cut in a blank forged sideways from the bar varied between the limits of 47 to 20, according as the grain ran longitudinally up the teeth or across them. By forging the blank axially much greater uniformity and a higher average strength was obtained, as in this case the grain ran round every tooth, all of which had a practically similar internal structure.

It is not difficult to form a mental picture of the way the grain of the metal is distorted in a simple case, such as the forging of a cylindrical billet into a flat circular blank, and one is therefore prepared to accept Mr. Brearly's explanation without demur. But by working with a billet made of concentric layers of differently-coloured wax, and sectioning it after forging, the ultimate arrangement of the grain is strikingly demonstrated. This has been done by Mr. H. F. Massey, M.I.Mech.E., and the results were reproduced in a paper read by him on Saturday last before the Manchester Association of Engineers.

Mr. Massey's paper was entitled "The Flow of Metal during Forging," and it was principally concerned with a study, by means of wax models, of the comparative effects of forging under a hammer or by means of a press. The general opinion among engineers is that the squeezing action of a press tends to benefit the metal by doing more work on the internal portions than can be effected by hitting the outside with a hammer. If one watches forgings, and particularly heavy ones, being made by the two processes, one cannot help a feeling that the press is doing the better work, and this idea is reflected in the greater popularity which the press enjoys in modern forges. How far the impression of greater thoroughness which the press produces on the mind is justified by actual facts is a matter which can only be settled by experience. Mr. Massey appears to have no doubt that the alleged superiority of press work has no foundation in fact, and he maintains that "the commonly accepted view that hammering expends itself on the outside of a forging, whereas pressing penetrates the whole substance of the forging, is erroneous."

This conclusion is based upon a number of experiments, some with wax billets and others with actual forgings. In order to determine how far the internal flow of wax corresponded with that of heated steel, Mr. Massey made a wax billet built up of nine ¼ in. layers of red and white wax alternately. This he stamped into the somewhat complicated shape of the link of a track-chain of a military tank, and then sectioned it to note the internal flow which had occurred. An iron track-link was stamped in the same dies, and when this was etched after being sectioned in a similar way, the internal structure was found to correspond so closely with that of the wax model that for all practical purposes it appeared that the nature of the internal flow could be taken as the same for wax as for metal. This point having been established, it was felt that confidence could be placed in the ability of a wax model to represent the phenomena occurring in a forging, particularly as subsequent check tests all tended to confirm the analogy. The paper to which we have referred covers a good deal of ground, but much of the reasoning depends upon the behaviour of a wax bar under the following conditions. The bar, 2¼ in. deep and 1 in. wide, built up of laminated wax, rested on a bottom pallet 1 in. wide, and was struck by an upper pallet of the same width. The blow had the effect of making a pair of fairly deep transverse notches across the bar. When the bar was looked at from one side, it was clear that the bottom of each notch formed one side of a triangular prism of wax, which had been forced bodily inwards towards the centre of the bar. The wedge action exerted by the sides of the prism created a tension in the bar, and the interior of the model was actually fractured along a vertical line reaching from point to point of the prisms.

The lesson of this experiment, which is confirmed by others, seems to be that the metal immediately acted upon by a flat tool does not necessarily flow out from beneath it as the tool is forced downwards, but constitutes a kind of wedge which is pushed into the forging ahead of the tool. This effect may be produced whether the tool is operated by a hammer or by a press. Those who had experience of H.E. shell-forging during the war will be familiar with the phenomenon. In such work the first operation on the heated billet was to press axially into it a flat-ended cylindrical punch, which descended nearly to the ultimate depth of the forged hole. Punches of this shape were used because they were found not only to require considerably less power than punches with tapered ends, but because they were also more durable. In the base of the finished shell it was not uncommon to find a more or less loose cone of metal, which sometimes came out altogether during the boring operation. This cone was certainly formed of metal which was originally at the upper end of the billet, but which had been driven down in front of the punch, to which it acted as a sort of false point. The cones corresponded, in fact, with the prisms formed when the wax bar was struck by the hammer, and their production showed that the slow squeezing action of a press might have no advantage over the sudden shock of a hammer blow, in so far as the proper flow of the metal is concerned.

In the instances we have given the surface of the article worked on was larger than that of the punch or pallet which attacked it, but when the conditions are reversed there is evidence of a similar wedge or cone formation. Several months ago, in describing the manufacture of ball bearings in these columns, we referred to the manner in which a hardened steel ball broke when tested to destruction under a press. The pressure of the pallets produces flats on the ball, which form the bases of small pointed cones which burst the ball by being driven into it. The appearance of the fractured ball usually shows these cones very distinctly. There is no doubt a good reason for believing that an effect which is seen in the hammering of a bar, the forging of a shell, and the crushing of a steel ball, may result generally from the working of plastic metal, whether by a hammer or a press. Mr. Massey presumes something of the same kind to happen when a circular forging is made between plain pallets. Prisms of metal, of which the bases are the narrow flats made by the pallets, are driven like wedges into the body of the forging, with the result that the metal in the centre of the latter is put into a state of tension. The effect is to make the end of the forged bar concave and to cause a tendency to piping in the interior. When a square bar is forged the prisms extend right to the centre, and the resulting pressure there makes the end of the bar convex, no tendency to piping existing in such a case.

One may admit that the action of a hammer and of a press may be similar in so far as the formation of prisms of metal in the forging is concerned, without subscribing to the conclusion of Mr. Massey which we have quoted above. The instinctive feeling that it is better to squeeze plastic metal into shape than to form it by hitting the external surface is likely to have some rational foundation. What the forger wanted to produce is a streamline flow of the displaced metal rather than a disruptive motion of the particles directly subjected to the force. To set up a streamline flow implies that every particle of the mass shall share in the disturbance, and shall be given a motion more or less proportional to its nearness to the centre of disturbance. To bring this about requires time. The relatively slow action of a press gives the necessary time, or, at any rate, it gives enough time greatly to facilitate the desired result. The point may be made clearer by considering what happens when lead or any

other metal is extruded through a die. A steadily maintained forward movement of the ram causes streamlines to form and results in the metal flowing in the only direction open to it. If, instead of being subjected to a steady pressure, the billet were to be struck sudden blows with a hammer, nobody would expect it to flow through the die because the force is not maintained long enough for streamlines to be formed. The more reluctant the metal is to flow the greater must be the duration of the pressure to cause a given flow. It follows that if an ingot is insufficiently heated even the slow action of a press may be too fast for the proper internal flow to be set up, and the resulting work will be more analogous to that of a hammer. In some of his illustrations accompanying his paper Mr. Massey shows that a round forging made under a press may show worse central piping than if the work is done by a hammer. Such a result is no doubt possible to obtain, but we think that with equal heating and commercial methods of working the press will generally make the better work.

TRAIN LOADS.

The question of improving train loads is one which is the daily concern of traffic managers and their staffs, and attention is continually directed to possible means of increasing wagon loading, and engine loading. The former is controlled by the efficiency of the traffic organisation, and, of course, by the nature of the traffic. Engine loading, on the other hand, is regulated both by the organisation of the traffic department and the physical features of the system, the latter often to a large extent dependent upon the skill of the engineering department and the facility with which alignment and other improvements can be financed.

When discussing train loading problems engineers in this country are perhaps too apt to consider merely our own conditions. We are, however, a nation of engineers, and British engineers and British capital have been responsible for many miles of railway outside the limits of these islands, and even outside those of the Empire. To confine the attention to this country alone limits the vision to a very small portion of the whole field.

Although in principle large train loads have long been considered desirable, comparatively little activity was to be noticed at home to break away from stereotyped methods until it was realised twenty or so years ago that in the United States trains of between 1,000 tons and 2,000 tons were being regularly hauled. If the subject was bruited it was at once remarked that American conditions could not be reproduced here, where goods traffic was run to a settled time-table. Nevertheless, the endeavour was made, and on one particular system with conspicuous success, to improve engine loading, while most companies turned far more attention to efficient wagon loading. Our march, fettered though it has been in innumerable ways, has been slowly forward. Not so very long ago 6-ton wagons were common on our systems; now we are working towards 12 tons, while on some lines high-capacity wagons are in restricted use. Development has been far more rapid in other countries, and in some the results attained are very remarkable.

The United States have moved ahead quicker than any country, till gross train loads in regular service now amount in some instances to from 12,000 tons to 16,000 tons. It is not to be imagined, of course, that such loads are common, but they are service loads for special traffic, and in no sense merely test loads to see what can be handled. Some time ago the Baltimore and Ohio introduced 80-ton cars. An engineer of prominence who might have been expected to be better informed, recently referred to the practice of the Baltimore and Ohio Railway as in this respect typical of the latest practice. The practice of this line is, however, now outclassed by that of others, as far as our information goes. For instance, the Norfolk and Western is operating 100-ton cars in trains of an aggregate gross weight of between 8,000 tons and 9,000 tons, while we believe the record to be held by the Virginian Railroad with a regular service of which the trains of 120-ton cars have even aggregated over 17,000 short tons gross, the normal figure ranging between 12,000 to 16,000 as mentioned above. These loads are, of course, for what is known as point-to-point traffic. They are, as a matter of fact, in use in the very special traffic of coal, from the mines to ports. No other country, so far as we are aware, approaches to anything like these figures.

The particular lines mentioned were specially built with a view to handling this class of traffic in big trains, but the loads now realised actually far exceed those originally contemplated. They have been rendered possible by the great increase in locomotive power, and by the adaptation of the air brake to modern requirements. The Virginian Railroad employs on these trains what is known as the double-capacity Westinghouse brake, while the Norfolk and Western stock has its large trains braked with the American straight air brake. The double-capacity Westinghouse brake is designed so as to proportion the braking force to the car when loaded and unloaded, instead of having the empty car over-braked, and the loaded car under-braked. This in large stock is of great importance. The American straight air brake is designed specially with a view to obtaining instantaneous and even braking effect throughout the rake of vehicles. The question of draw gear also comes in when loads reach these dimensions, and anything of the kind would be out of the question here unless specially high-capacity stock, with special draw gear, were introduced, supposing our loading gauge permitted.

In India the question of loading is gradually improving, and as engine power is increased, train working is reduced to more economical methods. On the metre-gauge the improvements is perhaps more marked than on the broad gauge. On the former loads up to 1,000 tons are being aimed at. Nowhere in the world, however, have narrow-gauge developments been so marked as in South Africa. Of these, Mr. H. Kelway-Bamber gave a very interesting summary before the Institution of Transport on Monday last. Mr. Kelway-Bamber's paper was entitled "Possibilities of Improving Train Loads," but his reference to this, or any other country except South Africa, was so brief that it might have been better if the title had been somewhat less general. The author, as is well known, is an ardent advocate of the big train load, with high-capacity stock. He recognises, as all must, who have had to do with English traffic, that sweeping changes here are not altogether practicable, though in certain classes of point-to-point traffic the big train of high-capacity stock might be introduced. Mr. Kelway-Bamber instanced as a suitable case the supply of London gas works from the Durham coalfields, and it appears that a trial for this service only just failed to be realised by the decontrol of the railways terminating the influence and assistance which the Ministry of Transport could bring to bear in certain quarters.

The interesting review which Mr. Kelway-Bamber gave of South African lines, drew attention to the great improvement which has been made on that system. Unfortunately the author's information only went back to the date of the Union, and in this way the whole case was not brought out, and, unintentionally no doubt, some injustice was done to the enlightened policy on some lines before the Union. It is not perhaps generally remembered that the railways of South Africa were as a rule laid down with a view to rushing traffic up-country. The conditions affecting construction at the time often precluded either thorough surveys or anything but hurried and cheap construction. In the course of time the flow of traffic has been reversed, and the bulk is now from inland to the ports, the export of coal, &c., having developed to the extent of millions of tons per annum. The natural result has been that on many sections grades which were little or no hindrance under conditions of moderate traffic when the balance was up-country, afterwards proved considerable handicaps to coastwise traffic.

On the Natal system, long before the date of the Union it was recognised that this had to be rectified, and in these columns we have at one time and another recorded what was being done to eliminate bad grades, by means of deviations, &c., to strengthen the road to withstand the increased loads, and to increase the power and capacity of locomotives and stock. At the present time the South African railways can probably show the highest development of any 3-ft. 6-in. system. They are running gross train loads on some sections reaching a maximum of 1,510 tons, while 1,100 tons and 1,200 tons are regularly worked on several sections, and these on lines with curves of about 5 chains radius, and grades of 1 in 30. In these trains modern stock including cars of 45 tons capacity is used, vacuum braked throughout.

As in America, the greatest development has been in the coal traffic. Natal early introduced powerful engines for this, though some of the designs did not prove satisfactory and have since been superceded, as is natural with the general progress of design. The 45-ton wagon in regular service on a 3-ft. 6-in. gauge is almost as remarkable a development as the 120-ton wagon on the broader gauge of America. Though the improvements in Natal had not reached their present pitch before the Union, even then the changes had been very striking. Improvements had made possible by 1909 trains of 910 tons on sections on which ten years before 220 tons had been the limit, and 720 tons in another case, had in ten years replaced 147-ton loads. Instances might be multiplied almost indefinitely, to show how effective had been the policy of those then in responsibility. The sums spent amounted to very many thousands of pounds, on deviations, &c.

It often happens that money has necessarily to be expended in this way as traffic develops. Roads built comparatively recently in the United States for special traffic were able to base their plans on conditions about which a good deal was known. Questions of finance could thus be met with fairly definite arguments, and the planning on an expensive scale in the first instance of such ore and coal roads may quite possibly be warranted. In the West, however, and in other new countries, lines usually have to be built cheaply or none can be built at all, and usually ideal conditions cannot be attained until traffic warrants improvements. This often means that the country gets a railway, and traffic develops, though working costs may be high. A time comes when the volume of traffic will warrant expenditure designed to reduce operating or maintenance costs. This question has been boldly tackled in South Africa where the improvements shown are extremely creditable to the managements.

THE LATE MR. EDWARD WINDSOR RICHARDS.

At the ripe age of ninety years there has passed away, to the regret of many friends, Mr. Edward Windsor Richards, who was for a long period prominently identified with the iron and steel trade, and particularly with the initial success of the basic steel process. Indeed, his name will always be almost as intimately associated with development of that process as those of its joint inventors—Sidney Gilchrist Thomas and his relative Percy Carlyle Gilchrist. The subject of our memoir was, in fact, the first to prove the actual value of this process of manufacturing steel by working it out upon so large a scale as to establish its commercial practicability and industrial advantages, and to stimulate the development of the many far-reaching possibilities that have since been so extensively and beneficially realised.

Born at Dowlais in August, 1831, he was the son of the general manager of the Rhymney Iron Works, so that it was natural that he and his brother should enter the ranks of iron and steel makers. He was educated at Monmouth and Christ's Hospital, and commenced his mechanical engineering training in 1847 by serving his time in the works of the Rhymney Iron Company, passing through their fitting shop and the drawing and surveyor's offices. He was put to start upon the arduous job of roll-turning. Engineering shops were not then equipped with such appliances as are now available for facilitating heavy work of that kind, and a tedious process it was; but of the qualities of cast-iron he thus gained a sound practical experience, which stood him in good stead for the responsible positions he attained later. There, too, he enjoyed the advantage of becoming acquainted with the earliest attempts at utilising the waste gas from blast furnaces. The first step was taken at Ystalyfera

by Mr. Budd, where the direct flame was applied to boilers or hot-blast pipes erected in immediate contiguity with the furnace mouth. Ebbw Vale speedily followed suit with the improvement of taking off the unburnt gas instead of the flame: first by an open cylinder filling the furnace throat, but leaving the top open; and afterwards by adopting the arrangement of conical hopper and charging bell, completely closing the furnace top, on the plan now so universally adopted with or without modification in details, the gas to be utilised being led off from the furnaces by suitable flues. As a result of this plan the steam for the blowing engines was raised entirely by the waste gas from the furnaces, by which also the blast was heated; and from 15 cwt. to 1 ton of coal was thereby saved per ton of pig-iron made.

Mr. Windsor Richards was appointed assistant engineer at the Tredegar Iron Works in 1854, and four years later he succeeded Mr. Josiah Richards as chief engineer, while, subsequently, in 1871, he became general manager of the Ebbw Vale works, where the addition of the extensive Bessemer steel department was carried out under his direction. During the Franco-German War Germany ceased to supply the spiegeleisen necessary for the manufacture of Bessemer steel, and without it the steel works in the country would have been compelled to stop. The Ebbw Vale Company had, however, at Brendon Hill, Somerset, spathic ore which contained sufficient manganese for the purpose, and Mr. Richards, designed and constructed a special blast furnace at Ebbw Vale for the manufacture of spiegeleisen. The company were thus able to supply their own wants of this material and to meet the needs of other steel-makers.

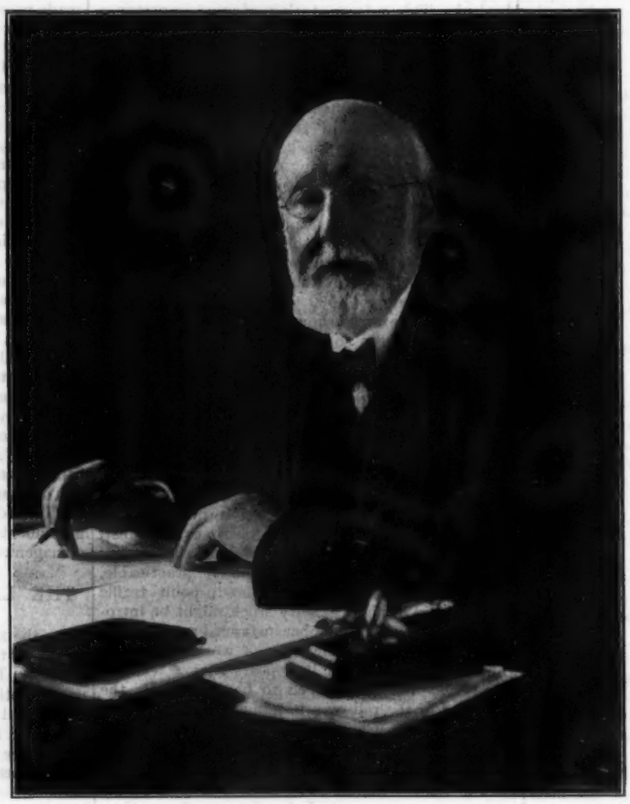
In 1875, the subject of our memoir was appointed to succeed Mr. Edward Williams as general manager of the iron works of Messrs. Bolckow and Vaughan, Middlesbrough. Here were erected at Eston in 1876, from his designs and under his supervision, the Cleveland Steel Works, including three hæmatite blast furnaces, in which hæmatite pig-iron was produced for use in acid-lined converters, for the manufacture of steel rails by the Bessemer process. Later the works were extended for carrying out the basic and open-hearth processes. The basic process, introduced by Mr. Sidney G. Thomas in 1878, first enabled Cleveland iron ore to be utilised for steel-making. It is to Mr. Richards' early efforts at the Cleveland Steel Works that the practical success of this process is generally ascribed. The direct conversion of molten iron from the blast furnace into steel according to the Bessemer method, which had previously been limited to purer ores free from phosphorus and sulphur, was thus rendered applicable to the much more extensive deposits of less pure ores contaminated with these ingredients. The utility of this method was thereby greatly enhanced, and a great stimulus was given to the production of steel throughout the world, and to its employment for structural purposes.

It was during his *regime* at Eston that Mr. Richards' career may, perhaps, be considered to have practically reached its zenith. The great work he did during that period won him the well-deserved award of the Bessemer gold medal, presented to him in 1884 by the Iron and Steel Institute. Throughout those thirteen years his energy and forethought were subjected to a severe continuous strain, and he began to feel the need for some relaxation of his weighty responsibilities. Retiring, therefore, from the post of managing director, he nevertheless retained his interest in the great enterprise in Cleveland, which had been so successfully developed under his control; and he continued on the board of directors, acting for some time as chairman.

A curious migration was then witnessed in his removal to the Low Moor Iron Works, where, during the ten years 1888–98, his vigorous efforts were successfully exerted in order to enable the long-famed brand of wrought-iron there manufactured to maintain its distinction in the teeth of the increasingly keen competition on the part of that very basic steel which he had himself been indefatigable in working up into the prominence it had so rapidly acquired. It was while at Low Moor that he expressed the opinion that even the mildest steel was not fit to be compared with the best Yorkshire iron for certain purposes. The reason he considered to lie in the fact that, in order to make steel castings of any use, it was necessary to add metalloids to the metal, whereby the steel was made brittle; whereas pure iron had no metalloid in it.

Returning in 1898 to the county in which his early years had been spent, he settled at Plâs Llecha, Tredunnock, near Caerleon, where he lived the remainder of his life and where he died. He qualified himself for the office of high sheriff of Monmouthshire, which he held in 1902. Though no longer personally responsible for the management of any large iron or steel works, his constant watchfulness over the welfare of the various large concerns with which he was still associated afforded ample scope for the occupation of his time and thought; and in addition his aid was sought in many metallurgical matters, upon which his long and varied experience enabled him to offer sound practical advice. He was a member of the Institution of Mechanical Engineers from 1866, and president during the two years 1896 and 1897. Of the Iron and Steel Institute he was a member from its formation in 1868, and was president in 1894. From 1881 he was also a member of the Institution of Civil Engineers.

On accepting in 1896 the presidency of the Institution of Mechanical Engineers, he modestly said of himself that, although he had been originally and for many years a mechanical engineer, for the last twenty years he had been drifting into the position more of an iron and steel manufacturer than of an engineer; and being much occupied in that branch of the profession, he feared he might not be thoroughly conversant with the recent improvements in the best engineering practice. An engineering friend, who had long known him well, said of him that he was a great traveller; he went into foreign countries, and saw with intelligent and observant eyes what was being done there; and what he saw he made a note of. In his presidential address in 1896 he was thus enabled to give a comprehensive survey of the best and most recent blast furnace practice in this country and abroad, upon which his own experience rendered him competent to offer appreciative and discriminating criticisms. To his mechanical and metallurgical knowledge, experience and ability he added an admirable power of saying whatever he had to say in a concise, clear, forcible and elegant way.



Photograph by Elliott and Fry.

THE LATE MR. EDWARD WINDSOR RICHARDS.

REINFORCED CONCRETE ROADS.—Mr. Andrew Warren, county surveyor (South Division), Devon, in a paper presented at the South-Western District meeting of the Institute of Municipal and County Engineer, held at Totnes, on Saturday, October 29, referred to an experimental section of reinforced concrete road opened to traffic in November, 1919. A thickness of from 6 in. to 10 in. was laid. The reinforcement was B.R.C. fabric, placed 2½ in. from the bed. Five weeks after laying, the road was tar-sprayed and opened to traffic. To-day it is reported to be as good as when laid. The surface has been tarred each year.

THE LATE SIR CHARLES DOUGLAS FOX.

A familiar figure in London circles has passed away in the death of Sir Charles Douglas Fox, which occurred on Sunday last. The son of the late Sir Charles Fox, Douglas was born in 1840, only little more than ten years after his father had helped to build the "Novelty" which competed at Rainhill. During the son's earlier years the father was engaged on many important works, and the erection by his father of the building now known as the Crystal Plaace, for the Great Exhibition of All Nations of 1851, was a source of great delight to the boy.

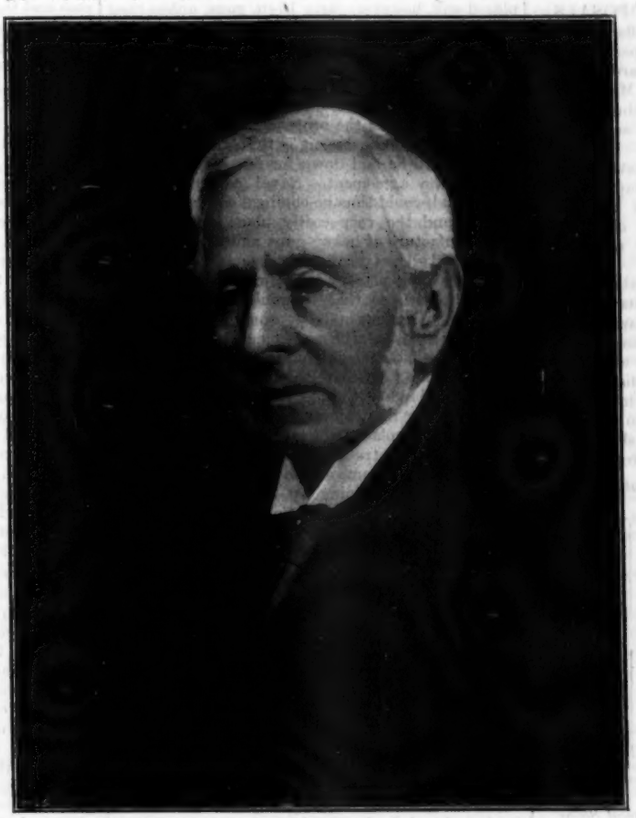
After his early education at the Cholmondeley School at Highgate, Douglas Fox studied at King's College, London, and at the age of 17 was articled to his father and acted for two of these years as resident engineer in charge of works, upon the Witney Railway. From 1860 to 1862 he acted in a similar capacity on the Ramsey Railway, and for some years subsequently was engineer to the Witney Railway. In 1863 he joined his father's firm as a partner; later Sir Francis Fox, his brother, was also taken into partnership, and subsequently his son was also taken into the firm, the name of which was changed from that of Sir C. Fox and Son, ultimately to that of Sir Douglas Fox and Partners.

Sir Douglas's work covered a very wide field, and he had close connection with many interesting developments at home and overseas, particularly in Australia and South Africa. He visited the United States on several occasions. His first visit to that country was with his father in 1857, and the following year he had the opportunity of visiting California with General Fremont. On this trip he rode alone through the famous Yosemite Valley, being one of the earlier travellers to penetrate that tract. Under such circumstances it was particularly felicitous that he should have been made president of the Institution of Civil Engineers in 1900 and so should have had the opportunity of receiving the American Civil and Mechanical Engineers who were entertained at the Guildhall on the occasion of their visit to London that year. Among the earlier work with which Sir Douglas Fox was connected was the construction of the London, Chatham and Dover Railway, the London, Brighton and South Coast Railway, and others. He was also consulting engineer to the Queensland Colonial Government, and was early connected with South Africa, in the construction of the Cape Town and Wellington Railway, the Cape Town and Wynberg Railway and other lines.

With Sir James Brunlees he acted as consulting engineer for the Mersey Tunnel, which was subsequently described by his brother Francis, in a paper contributed to the proceedings of the Institution of Civil Engineers in 1886. Sanction was obtained for this undertaking in 1866 by Sir Charles Fox, but it was not till 1879 that work was actually begun. It was completed in 1886 and was opened by H.R.H. the Prince of Wales. For his work in this connection the honour of knighthood was conferred upon Douglas Fox by Her Majesty Queen Victoria,

Another undertaking at home with which Sir Douglas was associated was the construction of the Liverpool Overhead Railway, for which he acted as joint consulting engineer with Mr. James H. Greathead, so well known in connection with tunnelling. This work is, as is well known, unique in this country, though on lines similar to those of the Elevated Railroad in New York. In the Liverpool case complications arose from the fact that the railway ran along the dock frontage, and bascule and swing bridges were introduced to cope with the difficulties. It may be recalled that Sir Douglas Fox was an enthusiastic advocate of standardisation, and was one of the early adherents to the movement which subsequently resulted in the formation of the British Engineering Standards Committee. This subject formed one of the many topics he discussed in his presidential address before the Institution of Civil Engineers in 1900, and it is interesting to note that for the Overhead Railway, which required something like 660 spans, and which would therefore appear to lend itself to standardised treatment, over 1,000 sheets of drawings were required, The Standards Committee, it may be remembered, was formed in 1901, the year after Sir Douglas was president. He served on the main committee from the time of its formation till early last year.

When the Manchester, Sheffield and Lincolnshire Railway became the Great Central and found its way to London, Sir Douglas Fox and his brother were responsible for the engineering work on the Southern and Metropolitan divisions of this railway. The features of this undertaking, so far as the sphere of Sir Douglas and his brother was concerned, were dealt with by Mr. Francis Douglas Fox in a paper read before the Institution of Civil Engineers in 1900, the author having acted as resident engineer on part of the work. The Metropolitan section included the Marylebone terminus, and this formed the subject of a paper before the same institution, contributed by Sir Douglas Fox's then chief engineering assistant, Mr. G. A. Hobson, and Mr. E. Wragge, who acted as resident engineer on the terminus works.



Photograph by Elliott and Fry.

The late Sir Charles Douglas Fox.

Sir Douglas Fox was also associated with tube railway development. It is noteworthy that his presidential address devoted a good deal of attention to the possible improvements in London railways, &c. Some years before electric traction was introduced on the District, Sir Douglas in this address referred to the benefits which would accrue from the abolition of steam on the Underground, and the possibilities of cleaning up the stations and making travelling on the system more amenable. Electric traction and the type of construction adopted on all the later tube railways, have indeed produced a revolution in urban travel. People very seldom nowadays give a thought to the changes thus brought about. For the same reasons of cleanliness, &c., Sir Douglas was a strong advocate of motor traction in London, and twenty-two years ago in the same address looked forward to the time when the motor vehicle would supersede the horse for town work. Although that stage has not been reached, Sir Douglas certainly lived long enough to witness remarkable changes in our streets. In connection with London traffic, Sir Douglas was associated with two tube railways, one the Great Northern and City, and the other the Charing Cross, Euston and Hampstead, the former opened in 1904 and the latter in 1907. We may also mention that for many years the firm have acted as consulting engineers to the Channel Tunnel and also to the North Wales hydro-electric works of the Aluminium Corporation.

Abroad, Sir Douglas Fox was for many years closely connected with South Africa, his name being associated with the Rhodesian Railways and the famous bridge over the Zambesi River at the Victoria Falls. Other undertakings in South Africa were the Beira Port and Railway, the Shiré Highlands Railway, the Benguella Railway, Bechuanaland Railway, the Trans-Zambesi Railway, and so on; in several of these he was associated with Sir Charles H. T. Metcalfe, Bart. In the Argentine, Brazil and Columbia, also, Sir Douglas's firm acted as consulting engineers to various railway com-

panies. Sir Douglas Fox was admitted as a member to the Institution of Civil Engineers in 1866, and elected to the council in 1884. We have already mentioned his presidency in 1899–1900. He was also a member of the Institution of Mechanical Engineers and of the Institution of Electrical Engineers. He patented numerous inventions connected with railway work, &c. In 1880 he was appointed lecturer to the School of Military Engineering, Chatham, his lectures dealing with light and temporary railways. The Institution of Civil Engineers awarded him at one time and another the Manby Premium, the Telford Medal and Telford Premium, for contributions to the proceedings. He was elected a Fellow of King's College (London) in 1887. He was a Justice of the Peace, and took a prominent part in many of the religious and philanthropic movements of his day, and a very large circle will undoubtedly regret his death.

NAVAL DISARMAMENT PROPOSALS.

It is perhaps premature, until details are available, to consider at any length the proposals for the reduction of naval armaments put forward on behalf of the United States Government by Mr. Hughes, the Secretary of State, at the Washington Conference on Saturday last, and since accepted in principle by Great Britain and Japan. Briefly the suggestion is that the three chief naval powers shall abandon or scrap a number of capital ships, the construction of which has either been commenced or is contemplated, and also destroy, or otherwise dispose of, a considerable number of obsolete or obsolescent vessels.

The following Table I shows the extent of the sacrifice to be made by the United States, Great Britain and Japan with regard to capital ships, and refers only to vessels on which some money has already been spent. Altogether it will be seen that 70 vessels, with an aggregate displacement tonnage of 1,878,043, are included in the list. Table II enables some comparisons to be drawn as to the relative strength in capital ships of the three navies if the United States proposals are

Table I.—*Number and Tonnage of Capital Ships to be Abandoned or Scrapped.*

State of Progress.	United States.		Great Britain.		Japan.	
	No.	Aggregate Tonnage.	No.	Aggregate Tonnage.	No.	Aggregate Tonnage.
Launched, but not completed ..	2	65,000	—	—	1	33,800
Building on berths	13*	552,800*	—	—	4	165,300
Not yet laid down ..	—	—	4	172,000	2	90,000
Old ships	15	227,740	19	411,375	10	159,828
Totals ..	30	845,740	23	583,375	17	448,928

* Including the West Virginia (32,600 tons) to be launched to-morrow.

Table II.—*Number and Tonnage of Capital Ships Remaining.*

Class.	United States.		Great Britain.		Japan.	
	No.	Aggregate Tonnage.	No.	Aggregate Tonnage.	No.	Aggregate Tonnage.
Battleships ..	18	500,250	18	458,250	6	178,320
Battle-cruisers ..	—	—	4	122,700	4	110,000
Totals ..	18	500,250	22	580,950	10	288,320

adopted without modification. It will be seen that 22 capital ships with a total tonnage of 580,950 will be left to Great Britain, 18 with a total tonnage of 500,250 to the United States, and 10 with a total tonnage of 288,320 to Japan. In this connection we would remark that the tonnages here given are taken from a White Paper prepared by the Admiralty in February last, and that the totals do not agree with those mentioned in Mr. Hughes' statement, which were 500,650 tons for the United States, 604,450 tons for Great Britain, and 299,700 tons for Japan.

A true comparison between the naval strengths of these three powers cannot however be drawn merely from a consideration of the numbers and tonnages of capital ships. Of the 22 ships left to this country, only the Hood has been launched since 1917, and even this vessel does not by any means incorporate the whole of the experience gained as a result of the Jutland battle. The United States, on the other hand, launched three battleships of the New Mexico class in 1917, the Tennessee and California in 1919, and the Maryland in 1920, all of which have been completed and will form part of the reduced American Navy. The three last-named American battleships are thus of later design than the Hood. The latest capital ships left to Japan will be the Nagato and the Hyuga, launched in 1919 and 1917, respectively. The former, it should be noted, mounts eight 16-in. guns, as also does the American battleship Maryland, whereas the largest guns mounted in any existing British ships are of 15-in. calibre. The new "Hoods," for which contracts have just been placed will, however, carry 16-in. guns, unless their construction is abandoned. These facts are, of course, well known to our representatives at the Conference, and will no doubt be considered when the details of the disarmament proposals are being settled.

Another point in the proposals which may prove difficult of accomplishment is that no replacement tonnage shall be laid down for ten years from the date of the agreement. Naval construction for that period would thus be confined entirely to light vessels, and the very costly plant required for the manufacture of heavy guns and armour would be rendered idle, as it cannot be used for other manufactures. Such plant would, however, be needed for future use, so that it would presumably be necessary to maintain it by some form of State subsidy. Moreover, the replacement is to be limited to a maximum of 500,000 tons for the United States, a like tonnage for Great Britain, and a tonnage of 300,000 for Japan. Subject to this maximum, and to the ten-year limitation above referred to, capital ships may be replaced when they are twenty years old, by new construction. This would involve a very heavy programme at the end of the ten years, with a possible opening up again of the whole question. This would be obviated by a gradual replacement of ships after they had reached an agreed age, the total tonnage of the respective Powers being fixed.

The maximum tonnage of future ships is to be limited to 35,000 tons. This is considerably less than the displacement of the Hood, which is 41,200 tons, so that this vessel could not be replaced. It may, however, be possible to produce a vessel of equal fighting qualities on the displacement allowed by the time that the replacement of the Hood would be permissible in the terms of the agreement. In general, the tonnage limitation on the capital ships of the future may lead to the employment of expensive special materials for construction, and this might easily outweigh any financial saving due to reduced displacement.

The proposals with regard to light cruisers, submarines, auxiliary craft, &c., have not yet been explained in full detail, but in considering them attention must be given to this country's special need for vessels for the protection of commerce. This, and the defence of a widely scattered Empire, will be the only duties of the British Navy in the future, as they have been in the past, whatever the outcome of the present negotiations may be. What we desire to see is the Navy maintained at sufficient strength for this purpose only; the necessary expenditure is only equivalent to an insurance premium on the future peace of the world.

HARBOUR DUES.

The main object served by the tonnage measurement of ships is not that of furnishing a criterion from which rival shipping companies can impress the public with the sizes of their respective fleets. It is for the purpose of calculating dock and harbour dues, and as these dues form an important item in the total cost of operating a ship, it is obviously important that the method of computing tonnage should be as fair as possible between vessels of different build. The measurement of tonnage presents considerable difficulty, since while the rules must be reasonably simple and not difficult to apply, the drawing up of a set of rules to meet these requirements, which shall at the same time be fair as between an ore carrier, a high-powered tug and a passenger liner may not be easy. This subject has long been one of controversy and discussion, and a further useful contribution to it was made by Mr. John Anderson in a paper read before the Institution of Engineers and Shipbuilders in Scotland last Tuesday.

What would appear to be the obvious way of computing the tonnage of a ship for the purpose of fixing harbour dues would be to measure how big she is. Harbour dues are paid for the services rendered to the shipping company by the harbour authorities, and these services obviously depend on the ship's dimensions. Her length determines the quay space she occupies. Her breadth settles the width of the dock gates through which she must pass and the depth of water she requires is fixed by her draught. The making of suitable arrangements for the docking of a ship will, from the point of view of this latter condition, frequently involve expensive dredging. In very many cases other facilities than mere docking accommodation are provided by the harbour authority. These facilities cover loading and unloading appliances and similar plant, but usually there would be no difficulty in making these the subject of a special charge.

Mr. Anderson points out that this very obvious method of estimating the tonnage of a ship by her dimensions was the one first employed, and the Act of Parliament of 1694 embodied in its rule for estimating the tonnage of English sea-going and coasting ships only the length, breadth, depth and a constant. Earlier law, passed in 1422, applied only to the carriage of coal and computation depended only on the length of keel. This law was for the purpose of computing the King's due of "two pence" per chaldron of coal shipped. In latter days the simple rule of 1694 was departed from, but that much may be said for it, is illustrated by the case made for measurement in terms of length, breadth and draught only by Mr. Anderson in the paper with which we are now concerned, and for the "block dimensions" system put forward by Mr. A. T. Wall in the paper read by him before the Institution of Naval Architects in 1919.

The present British method of computing ship tonnage depends on the measurement of the internal spaces except those which are assumed to be open and not protective enough for the carrying of cargo. From the total obtained by this measurement deductions are made for crew and navigating spaces, spaces above double-bottoms used for water ballast, deck gear compartments and space occupied by propelling machinery. The machinery space is not merely measured up and deducted from the total, but the deduction allowance is determined from the percentage volume of propelling power space to gross tonnage, in erratic ratio. The ratio is such that ships in which a ratio varies between 13 per cent. and 20 per cent. are favoured as compared with others. The advent of turbines and modern boilers has introduced a situation such that the modernisation of the propelling equipment of an old ship with consequent saving of engine-room space may push up its tonnage, and consequently the port and harbour dues it has to pay, very seriously. This point was dealt with in an illuminating way in the paper by Mr. Wall to which we have already referred.

In connection with this favouring of a 13 per cent. volume for machinery spaces over smaller volumes, Mr. Anderson remarks that if the object was to encourage fast vessels it has failed in modern practice. The law was made in 1854 and may have been suitable then, and if so, it would really be matter for surprise if it were suitable now. The effect of the law at present is to encourage useless light and air casings which are of no value to anyone, and may, as a matter of fact, be ruled out under official measurement as being unnecessary in extent. This tonnage rule to which we are referring has remained unaltered since 1854, except that in 1906 a maximum allowance of 55 per cent. of gross tonnage for propelling power space was made. This maximum was fixed at the instigation

of dock and harbour authorities which considered that the law as it stood before 1906 gave disproportionately low tonnages for high-powered ships. The contention was probably just, and large ships may well have carried a low tonnage rating. It is clear, however, that Mr. Anderson's proposal for tonnage based on exterior measurements only would eliminate the difficulty. High-powered ships would incidentally, if on a regular trade, benefit the harbour authorities by putting in more frequently than low-powered ones.

This question of engine-room space is not the only one in connection with the present rules to which criticism may be directed, and the sheltered spaces deemed unsuitable for the carriage of cargo raise difficulties particularly in the comparison of British and other rules. The Suez and Panama Canal rules in particular do not correspond with our own. This question of differences between existing rules we do not propose to enter into now beyond supporting Mr. Anderson's contention that an international conference on the subject and international agreement are very desirable. In the event of such a conference the case made by Mr. Anderson for a rating which would make dock dues some measure of the services rendered to the shipowner should be of much value. At the present time "tonnage" is supposed to be a measure of the earning power of a vessel. Dock dues are a form of rating; they are not a direct payment for services rendered. This system may be defended, but in practice it has led to dozens of different rules, and is obviously very difficult to apply fairly between different classes of ship. An absurd development of the present elaboration of rules is quoted by Mr. Anderson, who states that Government authorities have used tonnage to penalise those who do not meet their wishes in the matter of the lighting and ventilation of crew spaces. They have refused to deduct them from the gross tonnage, with the result that the owners are compelled to pay extra money to harbour authorities who have no interest in, or connection with, the matter.

TRADE UNION MONOPOLISTS AND ELECTRICITY SUPPLY.

The case of the Hackney Borough Council against Dore, which came before the King's Bench Division on November 14, illustrates the inconvenience repeatedly caused to the community by the refusal of certain trade unions to allow their members to handle work which has been commenced by non-unionists. The borough council were the undertakers for the supply of electricity in the borough of Hackney, and were under a statutory duty to supply it on certain statutory conditions. They had a distributing main within 50 yards from the premises of a Mr. A. C. Dore, and Mr. Dore called upon them to supply him with electricity for his premises. He had complied with all the necessary conditions, but trouble arose from the fact that his house had been wired by a man who was not a member of the Electrical Trades Union. All the employees of the council's electricity works were members of that union or acted in conjunction with it, and the men refused to make the connection to Mr. Dore's premises because the wiring had been done by a non-unionist. The council protested to the union and tried to induce them to allow the work to be done, but the union refused, and the council shrank or refrained from pressing the matter so far as to dismiss the men who refused to do the work, or to have the connection made by their electrical engineer at his own hands. Mr. Dore then brought a complaint against the council before a magistrate in respect of their failure to supply electric power to his premises.

As a result the magistrate found as a fact that (1) if the council had dismissed the men who refused to obey orders, or if their electrical engineer had himself made the connection, the result would *probably* have been that the Electrical Trades Union would have caused their men in the council's employment to give notice to determine their engagements, the jointers being able to give, at any time, an hour's notice; (2) if these men had left the council's service it would have been difficult or impossible to replace them by competent men outside the Electrical Trades Union, so that a large body of important workers would have been withdrawn from the Hackney electricity undertaking. Any interference with the Hackney undertaking would affect other undertakings in London physically connected with the Hackney works. The council contended that they had been prevented by *force majeure* from making the connection and giving the supply, but the magistrate held that their difficulties fell short of *force majeure*, and that they were guilty of an offence against their Lighting Order.

The council appealed to the King's Bench Division, but the court held that the magistrate was right in law. Mr. Justice Darling said that it was perfectly obvious that if the council had dismissed the two jointers who refused to do the work, the whole of the borough of Hackney would probably have been plunged into darkness, and the result would have been disastrous, and all because these two men had been ordered by their union not to do the work. Now if the magistrate had found that for a certainty all this would have happened, his lordship would have found that the council had been prevented by *force majeure* from supplying the electricity. The magistrate, however, had only said that this would *probably* have been the result, and there was no finding that it was certain that the men would have struck. On the facts as stated by the magistrate the case therefore fell short of *force majeure*, and the appeal must be dismissed.

It is difficult altogether to understand this reasoning, for it is obviously impossible for anyone, whether a magistrate or not, to say that if one person does a certain act, other persons will certainly do certain other acts; for no one can predict with certainty what other people will do under given circumstances. Even if the magistrate had found as a fact that if the council had dismissed the men, or their engineer had made the connection at his own hands their employees would have struck, this could only have meant that the magistrate thought that they would have struck. The form of finding in fact which Mr. Justice Darling thought might have been sufficient to let the court decide the case in favour of the council, thus seems to amount practically to the same thing as the finding on which the court decided the case against them. Meantime Mr. Dore is presumably without his electricity, but the result of the judgment will be to make it incumbent on the council to take more resolute steps to overcome the trade union's opposition and to give the supply.

NOTES.

The Education of Engineers.

The Committee appointed by the Institution of Engineers and Shipbuilders in Scotland, to consider the question of the best course of study for engineers has issued a second report which supplements that published some eighteen months ago. The committee refers to the fact that engineering students are admitted to Scottish Universities without being required to pass an entrance examination, provided they have taken the "Higher Leaving Certificate" in their school course. The course for this higher leaving certificate is held to be satisfactory for boys intending to take up engineering, and the committee does not recommend the teaching of engineering subjects in school, though it is thought that a higher standard should be demanded in practical solid geometry. As regards further theoretical training the "sandwich" system is highly commended in the report, and is said to avoid the difficulties met with when either the complete college course or the complete workshop apprenticeship is taken first. The committee holds, however, that the apprentice should pass between one and two years in the shops before proceeding to college, and that during this period attendance at evening classes should be encouraged. The complete college course in engineering should be, it is recommended, extended to four years; as only the exceptional student can attain the standard now demanded in three. Should this policy be adopted, it is to be hoped that provision will be made for the exceptional student, and that he will not be compelled to keep in step with the less able. As regards evening classes, the committee advises that the standard aimed at should be such as to afford a good grounding in the principles of engineering and applied science, and yet not be out of the reach of the average student who follows it for a course of five winters. With respect to workshop training, the committee recommends that more definite instruction in craftmanship be provided. In the past the apprentice has had to rely on the goodwill of the journeyman with whom they may be associated. In some cases this journeyman has a jealous dislike of handing on his craft knowledge, and in others with all the good will in the world, he may lack the gift of imparting what he knows to others.

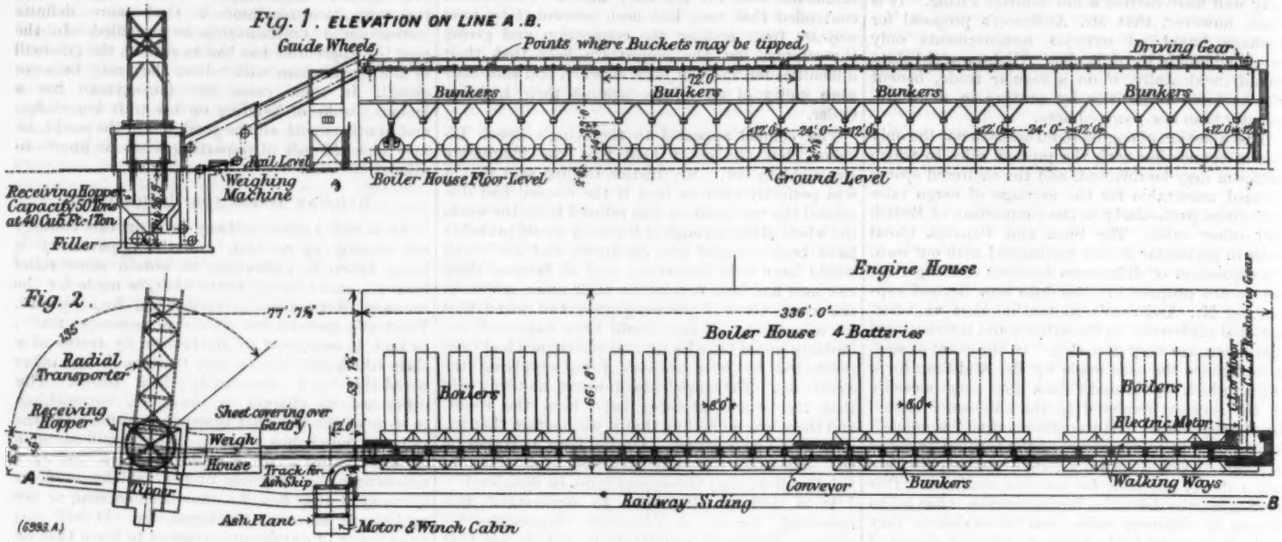
Railway Rates for Periodicals.

As is well known, railway rates in this country are undergoing revision, and the opportunity is being taken to endeavour to obtain some relief from the inordinately heavy charges made for the carriage of periodicals, magazines, &c., by rail. The traffic goes by fast special or passenger train; in fact, is conveyed to destination by trains of a class which also handle fish, fruit, milk and other perishable and necessarily fast traffic. The difference in charges is, however, astonishing, in spite of the fact that newspaper traffic gives the railways much less trouble, since it will stand a certain amount of roughish handling, and does not necessitate the cleansing of the vehicles used, as is essential after fish, &c., has been carried, to say nothing of barrows, platforms, &c. It will surprise many of our country readers to learn that on a typical 168-mile journey the London newspaper is charged for carriage at the rate of 8s. 2d. per cwt. whereas herrings in brine—one of the messiest of commodities, though attractive enough when transformed by culinary art—are charged for a similar distance only 1s. 9d. per cwt. We do not, of course, advocate anything which will tend to increase the cost of furnishing the breakfast table; rather we advocate, somewhat naturally, a reduction of the newspaper rates. It stands to reason that if a troublesome, perishable and irregular traffic like fish can be carried at these rates, the regular traffic from a trade which functions with clockwork precision, and which causes no nuisance to the companies, ought to be handled for not more than the same rates, to say the least of it. The example we have cited may appear to be intentionally chosen as an extreme. It admittedly shows more difference than some, but many others could be cited. Common fish, for instance, for 272 miles costs per cwt. 3*s.* 6*d.* The comparative charge for newspapers is 8*s.* 7*d.* Prime fish, 268 miles, 4*s.* 7*d.*; newspapers, 8*s.* 7*d.* Milk, 143 miles, 1*s.* 8*d.* per cwt.; newspapers, 8*s.* 2*d.* Milk churns are returned free, though they bulk as large as full cans; newspaper returns are not carried except at half rates. The charges for fruit, which is carried at either company's or owner's risk, may be about 5*s.*, against 8*s.* 2*d.* for the newspapers at owner's risk only, and charges on meat in most cases run out at very considerably below (often not more than two-thirds) the cost of carriage of newspapers. In view of these figures, and the great difference in the nature of the traffics, on the score of ease of handling and of cleanliness, and its regularity as contrasted with the spasmodic nature of the perishable traffics quoted, there is a strong case for the reconsideration and reduction of the present charges, for papers, which are altogether out of proportion to the selling price of the goods carried. It is to be hoped that in the forthcoming changes the authorities will see the justice of a revision in a downward direction, to place this traffic on a fair basis as compared with others.

Model General Conditions for Contracts.—The revision of the Institution of Electrical Engineers' Model General Conditions for Contracts which began in April, 1920, was completed last session, and a new edition was published on the 1st of this month. In addition to the members of the Committee of Revision nominated by the I.E.E., the committee included a number of representatives of other associations within, or closely connected with, the electrical industry, and through these representatives the committee had the benefit of the views of the governing bodies of the various associations interested in the Model General Conditions for Contracts.

COAL AND ASH-HANDLING PLANT; ROYAL NAVAL CORDITE FACTORY, POOLE.

SIR DOUGLAS FOX AND PARTNERS, MM.INST.C.E., ENGINEERS, WESTMINSTER; MESSRS. SPENCER AND CO., LTD., MELKSHAM, CONTRACTORS.



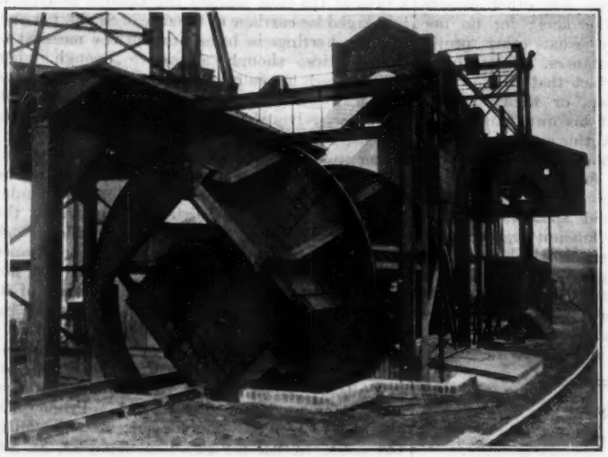


FIG. 3.

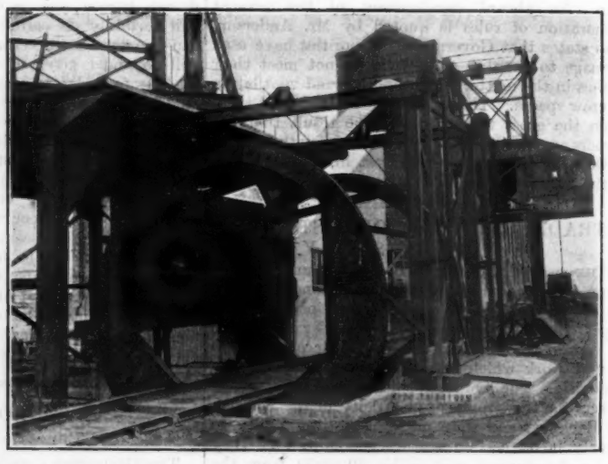


FIG. 4.

COAL AND ASH-HANDLING PLANT OF THE ROYAL NAVAL CORDITE FACTORY, NEAR POOLE.

By GEORGE FREDERICK ZIMMER, A.M.Inst.C.E.

A COAL and ash-handling installation which differs materially from the usual practice is illustrated in Figs. 1 and 2 above, which show it outline plan and elevation; Figs. 3, 4 and 7, show views of the most important parts of the installation.

The railway sidings on which the coal arrives and from which the ashes leave, run alongside and parallel with the boiler-house; the full trucks arrive on the inner track and pass over an unusually large track hopper into which the coal is dumped by the truck tippler, by completely overturning the trucks. The receiving hopper has a capacity of 50 tons, its upper portion is formed of concrete while the lower hoppered portion is built of steel plates.

The Tippler.—This stands over the receiving hopper and is of the side-tipping type. It can therefore unload all kinds of open mineral trucks of from 10 tons to 12 tons capacity; it is immaterial whether they are provided with or are without, hinged end doors.

Before proceeding with a general description of this tippler it will be well to point out that such revolving tipplers are somewhat uncommon. Few of them have so far been introduced. They are more expensive in first cost, but in addition to the great advantage, already mentioned, that all types of wagons can be tipped, the unloading apparatus does not involve lifting the truck either as a whole or at one end. In consequence the power expenditure involved is small since the truck is practically revolved longitudinally, and as nearly as possible round its centre of gravity. Incidentally, the trucks are not exposed to any strain since they remain on their four wheels during the unloading process. Whether the damage caused by end tipplers to coal wagons is real or imaginary, cannot here be discussed, but some of the railway companies are inclined to take the former view and object to that method.

The greatest drawback to the end tip is, however, that the coal consumer must always order his coal from the colliery with the stipulation that it is to be loaded into end-door wagons, and when he gets it he cannot be sure that all the wagons arrive with the end door foremost, which is indispensable, unless he is prepared to add a turntable to his equipment by which he can reverse wagons which do not reach him the right way on, or he must go to the expense of having his tipping device in duplicate, one on either side of his receiving hopper, of which the one unloads those with the end door foremost and the other those the other way round.

The construction of the Spencer truck tippler used in this installation consists essentially of a structural steel framework and a revolving cage, which latter comprises two strong rings, supported on rollers, see Fig. 3. In this cage a short continuation of the standard rail track is provided which in the initial position of the tippler is in alignment with the rest of the permanent way on both sides; the coal truck is secured in this cage by an automatic clamping gear for holding it firmly in position during the tipping operation. The cage is rotated by a shaft and pinions which gear into cast steel toothed quadrants, bolted to the rings of the cage; an electro-motor of 7½ b.h.p., running at 750 r.p.m., actuates this shaft through worm and spur reduction gear. The four idle rollers on which the cage revolves are not shown on Fig. 3, being beneath ground level.

A length of standard track, is mentioned as running from end to end of the cage, this is, however, not a fixture therein, but forms part of a platform within the cage; this platform is composed of rolled steel sections and plates, supported on cast steel rollers. It can therefore slide to one side in the cage as this begins to revolve. This side motion is performed automatically by an arrangement of cams, and the platform comes to rest as soon as the truck touches and rests against a matting fender, which is as long as the cage; this is clearly shown in the illustration, Fig. 4. Since this fender is a portion of the cage, it will be seen that the truck, which is now slightly out of centre with the cage, snugly rests with all projecting boltheads, straps, &c., bedded, and the load uniformly distributed; this is necessary since a continuation of the rotary motion of the cage imposes the whole weight of the wagon and load upon the fender. The side motion of the platform is governed by a cast-iron plate on which the rollers run.

Simultaneously with this movement two steel clamping bars are lowered automatically until they rest on top of the truck, these two bars are shown on the view, Fig. 4, starting just above the fender. Two steel wire ropes are reeved over sheaves within the clamping bars, and one end of each rope is secured to the cage, while the other is led over two guide pulleys shown on the top of the steel structure and provided

with differential balance weights which rest normally on the ground, the tops of these weights are just visible above the ground in Fig. 4. The rotation of the cage tightens the steel ropes and presses the bars tightly upon the top of the truck and eventually all the weights are lifted off the ground.

All these operations are automatically performed and in the rotation mentioned, and the truck is now securely held. Under these conditions the cage completes its rotary motion to a pre-determined position in which the contents of the wagon are deposited in the track hopper. A truck in this position is shown in Fig. 3; this also shows the weights in their raised position, and the underside of the sliding platform.

As soon as the truck is empty the driving shaft is reversed and revolved slowly in the opposite direction, with the result that all the operations are now reversed, and by the time the truck has again reached its initial position it is ready to be pushed out by the next wagon to be discharged. Under ordinary conditions this tippler can discharge standard trucks at the rate of 12 per hour.

Fig. 5.

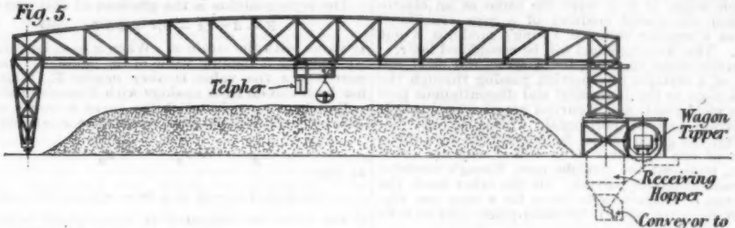
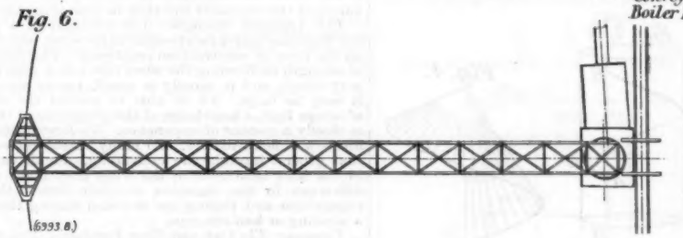


Fig. 6.



(6993 8)

FIG. 7.

Radial Transporter.—The coal is next dealt with by a radial transporter; it is of the bridge type and about 240 ft. long, and is capable of moving radially through an angle of 130 deg. The inner end of this transporter is supported on a turntable resting on a steel superstructure (Figs. 5 to 7). The outer end is carried by a structural steel tower mounted on two bogie carriages which run on a radial track; the radial motion of this transporter is effected by two reversible electro-motors of 5 h.p. each, one of which is geared through four sets of spur gearing, to each bogie carriage, imparting a travelling speed of 20 ft. per minute to the outer end of the transporter. The telpher machine travels from end to end on a mono-rail track below the main girder body on four manganese steel running wheels at a speed of 600 ft. per minute. The telpher machine is fitted with two electric motors, both fitted with solenoid brakes; one, of 10 h.p., travels the telpher by a rocker-joint chain drive; the other is of 30 h.p. and manipulates the grab by three sets of spur gearing and a drum with right and left-handed grooves. The grab is of the Priestman, treble-chain type, with a capacity of 2 tons; the hoisting speed is 100 ft. per minute.

Coal is grabbed from the receiving hopper through an opening near the turntable, and discharged at any point of the storage area. A driver's cabin is suspended from the telpher frame and contains the controlling gear, switches, &c., for both hoisting and traversing which are all within easy reach, and from his elevated position the driver has a commanding view over the whole storage area. We will now describe how the coal is delivered into the bunkers over the boilers, which are grouped in four batteries of six boilers each, together 24 boilers, over each of which there is a bunker. The rate at which coal has to be conveyed to these bunkers is 20 tons per hour.

A gravity bucket conveyor is here employed, and its path can readily be followed from the elevation, Fig. 1; the conveyor proper is too well known to need any further description. It is fed by means of a regulating slide at the base of the receiving hopper. This delivers the coal into a rotary filler which doles out the correct quantity to each of the gravity buckets. The speed of the conveyor is 45 ft. per minute, and it is driven by a 12 b.h.p. motor and worm and spur reduction gear. Coal is distributed as desired to any of the bunkers by a bucket tipping gear located at each bunker compartment. The supply of coal to the boilers is controlled by quadrant valves fitted to the bunker outlets and then conducted to automatic stoker hoppers by steel breeches shoots. On its lower horizontal run the gravity bucket conveyor passes a Blake-Denison automatic weigher of the continuous type which records the weight of coal passed. The floating part of the conveyor, in connection with the scales, comprises four buckets.

When no coal is being unloaded at the works the supply has to be taken from the reserve store, in this case the telpher grab of the transporter is used to take the coal from any part of the storage area and shoot it into the same receiving hopper into which the railway wagons are tipped and from this it is taken by conveyor, as described.

Ash-Handling Plant.—A simple ash-handling plant disposes of the furnace refuse. For this purpose six steel skips are provided together with suitable trolleys on which they are moved to or from the different boilers. At the end of the boiler house a steel tower has been erected, which supports an overhead ash bunker; this steel structure spans the railway siding, see Figs. 1 and 2. A hoisting apparatus is fitted to the steel tower for lifting the skips from the trolleys and emptying the contents into the bunkers. The hoisting speed of this is at the rate of 53 ft. per minute, and that of traversing 106 ft. per minute. The two hoisting drums for this operation are each driven by a 4 b.h.p. motor and spur gearing, and each is furnished with a solenoid brake. A cabin projects from the tower, from which all motions are controlled, see Fig. 4 in the middle distance. The outlet at the bunker is provided with quadrant valves which are manipulated by hand chains from the ground, and the ashes are thus loaded into the railway trucks on the siding beneath, by hinged shoots, adjusted by a hand winch.

Incidentally, the photographic views, Figs. 3, 4 and 7, show the boiler-house in the distance, the two sidings for the full and empty trucks. The latter is nearest the boiler-house and passes under the ash bunker, which is seen just below the tippler. The inclined gantry which protects the gravity bucket conveyor from the weather may also be seen.

The consulting engineers were Sir Douglas Fox and Partners, M.M.Inst.C.E., and the contractors were Messrs. Spencer and Co., Limited, of Melksham, Wiltshire and London.

THE FRACTURE OF WIRE IN STEEL ROPES.*

By Dr. E. M. Horsburgh, Lecturer in Technical Mathematics, University of Edinburgh.

In the first part of this paper fundamental principles are discussed, and an attempt is made to deal with some problems in steel ropes in which a general agreement has not yet been reached. The latter part is concerned chiefly with some of the writer's experimental observations on rope wires. This paper has been restricted to certain headings, and makes no attempt to cover the whole field.

The experimental work was carried out at Brunton's Research Laboratories, Wiremills, Musselburgh. The writer begs to express his thanks to Mr. J. D. Brunton and to the members of his staff for the admirable facilities afforded.

Forces in the Rope Wires.—If a weight W, Fig. 1, be supported by strings whose tensions are $T_1, T_2 \ldots$, making angles $\theta_1, \theta_2 \ldots$ with the vertical, then, on resolving vertically, since there is equilibrium, $\Sigma T \cos \theta = W$. The horizontal components may also be treated in the usual way, by resolving, or by the polygon of forces.

Hence if a rope (hanging vertically as the simplest instance) sustain a load W, it is natural to assume that the same conditions would hold for the wires, viz.,

* Paper read before the British Association, at Edinburgh, September 8, 1921.

$\Sigma T \cos\theta = W$, where T is the tension of a wire making an angle θ with the vertical, these wires being taken over a cross-section of the rope. This seems to have been generally accepted.

Now if $T = w \sec\theta$ be the tension at any point of a rope wire which sustains the load w, then as $\theta \to \frac{\pi}{2}$ $T \to \infty$; *i.e.*, fracture would occur long before θ approached this value. From this equation, too, it would follow that the tension in a rope wire would vary periodically along its length, since the inclination of the wire undergoes a cyclic change, in a straight rope, and it would follow, too, that when a rope breaks in direct tension it would fail by the wires giving way at those points within a pitch-length wherever θ were greatest. Also it would appear that a rope could not be used if the angle of the helix were small, *i.e.*, if the angle of the lay approached $\frac{\pi}{2}$.

As neither of the latter considerations is borne out in practice a further examination of the hypothesis is necessary.

A model, as shown in Fig. 2, representing a portion of an ideal rope may be formed in the following way. Consider a smooth, weightless cylindrical core with a string or wire H A C D B K, where H A B K is a generator of the vertical cylinder and A C D B a convolution. The curved portion will lie in a helix, as in a one-strand rope. Let the wire sustain a load W. Then T = W in H A and B K. In the convolution A C D B the additional forces introduced are the reactions which are normal to the cylinder, so it appears that the tension is unaltered. Since the radius of the cylinder, and the pitch of the helix, are known, the radius of curvature ρ of the helix is known, and the pressure p between the curved portion and the cylinder is given by the equation $T = p\rho$. The tension accordingly is unaltered throughout the length of the wire. This is similar to what occurs in taking a flexible cord round one or more smooth pulleys, and thus the conclusion, though perhaps unexpected, connects up with a well-known result in statics.

In making a model of this arrangement small guide pulleys would be placed at A and B.

It will be objected, however, that in a rope the wires do not move without friction. If a cord be wrapped round a rough post, where μ is the coefficient of friction, and θ the angle of wrap, the tensions T and T_0 are given by the equation $T = T_0 e^{\mu\theta}$, when slipping is about to occur. If this be applied in following out the convolutions of a single wire in a long winding rope, the factor $e^{\mu\theta}$ would become very great, as θ would be great, and μ a considerable fraction. This would lead to the paradoxical result that the tension at one end of each wire would be nearly zero and that at the other end nearly infinite, *i.e.*, that the rope would not sustain anything. The application of this result accordingly would be absurd.

Referring again to the model, suppose next that the core is rough though still weightless. Then $T = T_0$ at A H and B K, as there is no slipping and the core is weightless. Hence the tension is still constant throughout the wire in the model. Though the model does not represent accurately what occurs in a steel rope, yet it enables conclusions to be drawn which should be true within reasonable limits.

Considered as a rope, the "rough post" referred to, round which the wire is wrapped, is no longer fixed, but can yield as the wire is extended. Hence the above frictional equation does not apply, but the conditions resemble those of a smooth pulley instead. Thus no appreciable differences of tension will occur along the wire, *i.e.*, its tension will be the same throughout.

Now experiments show that the strength even of a new rope is somewhat less than the sum of the strengths, or aggregate, of the constituent wires. Wherein lies this difference?

In the first place, as mentioned, the ideal conditions of the model do not hold, but also the wire is bent out of the straight, and, so has bending stresses superposed on the tensile stress. In calculations of steel structural members we know that a very small amount of bending (well within the elastic limit) produces high bending stresses. These added to a high tensile stress due to the load suggest immediate fracture of the rope. But this again does not occur. The material has undergone the deformation of wire drawing, and though in the braiding the wire is further permanently deformed, the steel accommodates itself to the new conditions, undergoing the usual phenomena observed in deformation above the elastic limit. Thus there will be practically no immediate evil effects noticeable in new rope, though there will be a certain slight weakening of the rope wires.

The load sustained introduces also couples acting on the wires.

These produce bending and torsion, but their effects are slight compared with the tensile effect. They are imperfect helical spring effects, and do not affect the strength of the rope so long as it still preserves its elasticity.

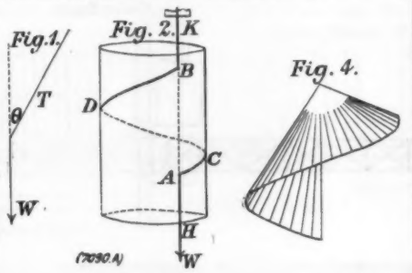
The Rope Modulus.—A quantity frequently asked from the rope-maker is the "Modulus of Elasticity" of the rope. This name implies a constant quantity like Young's elastic modulus E, so that the product of it and the strain would give the stress. But a Young's modulus refers to the material, *e.g.*, steel, and not to the shape in which it occurs, whether tie, strut, beam, or rope. The steel in a rope has the Young's modulus of the steel in the condition in which it is being used, and which is altered by hot or cold treatment, and this value may be determined in any of the usual ways.

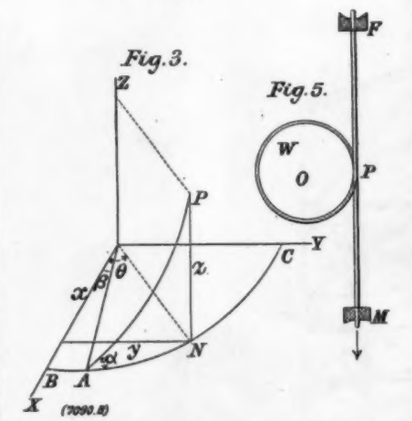
This quantity has also been discussed with regard to the effect of bending a steel rope, and the deterioration that occurs when a rope is under combined tension and bending, as in the case of a winding rope passing over a sheave.

Usually the stress due to bending has been calculated from the formula for the bending of an elastic bar, and the stress so obtained added to the tensile stress. As this bending stress was manifestly too high, the bending formula was modified by substituting instead of E some fraction of E, chosen more or less at random.

This, of course, is wrong. It is erroneous to treat a flexible rope whose constituent wires are not even straight, and which are capable of considerable slipping over each other, as if it were the same as an elastic beam, and the elastic modulus of a rope considered merely as a smaller value of Young's modulus is out of place. This bending effect will be considered later.

The strain-stress diagram for a structural steel rod consists of a straight line portion passing through the origin, a more or less horizontal and discontinuous part near the yield-point, and a curved arc convex upwards if the strain axis be horizontal. Owing to the discontinuity, the graph cannot be represented by a single function of one variable. If $p = E e$, with the usual notation, represent the straight part, Young's modulus is the gradient of this portion. On the other hand, the strain-stress or characteristic curve for a rope (see Fig. 14) is not discontinuous till breaking-point, and so may





be represented by a single equation for the range considered. It may be observed, in passing, that the extension-load curve for steel wire is somewhat similar to this curve away from the origin, as it does not possess a discontinuous yield-point.

In the case of the rope, if y be the stress or load and x the strain, y may be expressed empirically as a function of x, by a few terms, or in an ascending power series. For convenience, representation by as few terms as possible is desirable, consistent with fitting to the observed facts.

The curve practically touches the x-axis at the origin owing to the springiness of the rope, it then has a nearly straight ascending portion with a point of inflexion, and then it becomes convex upwards and rather flat.

One obvious assumption for the shape would be $y = A x^M (B - x)$, where the constants A, B, M are to be fitted for the best results. It will be found, however, that this form is not satisfactory, as the part more distant from the origin is not well represented.

From laboratory tests it is seen that the curve has a point of inflection, say (a, c), where the gradient F is easily determined. Also the curve lies close to the inflectional tangent for a considerable range, and passes through the origin, nearly touching the x-axis, but very rapidly approaching the inflectional tangent. At about three-quarters of the ultimate extension a good observation of load and elongation may be obtained for curve fitting, but this should not be taken too near breaking-point, as a number of wires will have fractured, so vitiating the observation for a strain-stress curve.

As the portion of curve near the point of inflection is of special importance, y may be expanded in ascending powers of $(x - a)$ so that since $(x - a)$ is small

$$y = \alpha + \beta (x - a) + \beta_1 (x-a)^2 + \gamma (x-a)^3 + \delta (x-a)^4 +$$

Suppose that a good enough approximation is obtained by terminating the series at the fifth term. It is required to fit this to the observations. Normal equations are hardly necessary. The constants α, β, β_1, γ, δ are required. From the observations we have by inspection $\alpha = c$, and $\beta = F$. Also since $y_a'' = 0$, $\beta_1 = 0$. Further, $c - F a - \gamma a^3 + \delta a^4 = 0$, since the curve is to pass through the origin. For the last condition the observation when $x = 3a$ seems simplest and quite effective. Let h be the corresponding ordinate. Then

$$h = c + F\,2a + 8\,\gamma\,a^3 + 16\,\delta\,a^4.$$

Solving for γ and δ the remaining constants, we have:

$$\gamma = \frac{h + 15c - 18aF}{24a^3} \qquad \delta = \frac{h + 6aF - 9c}{24a^4}$$

The curve can now be fitted to any observations.

The rope modulus is the gradient of this curve, viz.,

$$F + 3\gamma(x - a)^2 + 4\delta(x - a)^3$$

It varies with the strain x. When $x = a$, its value is F, which is the maximum value of the modulus. In places near $x = a$ the value is very nearly F. This letter has been chosen from analogy with Young's modulus E.

For those ropes in which the curve is nearly straight over an exceptionally great range for x we should have:

$$y_a'' = 0,\ y_a''' = 0,\ y_a^{IV} = 0$$

so that

$$y = \alpha + \beta(x - a) + \epsilon(x - a)^5 + \zeta(x - a)^6$$

if the series be truncated at the seventh term. The values of the constants will then be determined as above.

The Aggregate Strength.—The strength of a rope is less than the aggregate strength of its wires, and depends on the form of construction employed. The diminution of strength on forming the wires into a new rope may be very small, and it usually is small, but in some cases it may be large. To be able to predict the strength of a rope from a knowledge of the properties of the wires is chiefly a matter of experience. To foretell its active life is a difficult matter. So many considerations arise that general formulæ are unavailing. Small variations in the heat treatment of the wires may make a great difference in the duration of their lives. Constant supervision and testing are required during the life of a winding or haulage rope.

Tension: The Cup and Cone Fracture.—The cup and cone fracture in rope wire is very distinct. A suggestion regarding the origin of this phenomenon may not be out of place.

In a rod under tension shear stress is set up, and this may be a determining influence in failure. The direction of shear at any point of an axially-loaded cylindrical bar makes a constant angle $\left(\frac{\pi}{2} - \alpha\right)$ with the axis of the cylinder. Such a line is a helix of angle α, where α is in the neighbourhood of $\pi/4$, the value depending on the internal friction of the particles of the material. The actual determination of what occurs in the interior of the bar is difficult to observe, as the material is opaque, and even the preparation of a slide for the microscope produces changes in the visible parts. Slip lines can often be seen on the surface of a strained cylindrical bar. They are helices and are traces of surfaces within the cylinder, since slip must occur over a surface.

To visualise such a system, consider the helices of angle α passing through a radial line of the cylinder. These are found (Fig. 3) to be on the surface.

$$z^2 = \tan^2\alpha\,(x^2 + y^2)\,(\arctan\frac{y}{x} - \beta)^2$$

This is a transcendental cone (see Fig. 4). If the point (x, y, z) be on the surface, so is $(\lambda x, \lambda y, \lambda z)$. It consists of a number of leaves folded round each other. The equation shows that coaxial cylinders cut it in helices of angle α. The arbitrary constant β denotes a onefold infinity of such surfaces, obtained by rotating the radial line. A model of this surface is not difficult to make.

If slip were to occur on such a surface, the vertex, a point on the axis of the cylinder, would be a point of weakness in the material, since the shear, as will be seen in the model, would pick out all the planes of weakness in the central granules, causing fracture to start there. Thus, in the general case, failure would begin at the centre of the bar, and this would gradually extend radially outwards in a plane perpendicular to the axis of the wire as the loading increased.

If the metal were hard and brittle this crack would extend as an increasing circle right across the bar, forming a flat or plane fracture.

If the metal were ductile the crack would not extend right across, as the material of the outer layers would continue to flow. Where the speed of flow was great the cross-section would diminish, so forming the waist. In the interior of the outer portion the transcendental cone has a fold like a simple helicoid. The family of these cones would be touched by a cone of rotation coaxial with the cylinder. The material, if ductile, would tend to slide along the surface of this cone, its angle being such as to give the weakest shearing surface. The final parting would be by slip along the curved surface of this cone. This would produce the usual cup and cone formation. As the cones may have either their convexity or concavity turned upwards, the actual failure need not be along a single cone, but may occur over parts of two or even more cones.

Abnormal cases may occur in which the failure does not begin at the centre, owing to a flaw or inclusion in the material, which localises the stress and so raises it at the point considered, causing the crack to commence there.

Similar results may be given by nicks, punch marks, or ineffective gripping. Photographs of an interesting collection of tensile fractures are shown in a paper by Dr. G. H. Gulliver, in *The Technical Inspection Association Gazette*, February, 1921. Failures partly along the cone of rotation and partly along leaves of the tran-

scendental cone may be the causes of the rarer helicoidal fractures shown by the delta metal specimens. The cup and cone formation is very distinct in rope wire, owing partly to the toughness of the material, partly to the result of drawing in causing flow, and also, probably, to the skin effect in wire.

Frequently in wire tests failure occurs at the grips owing to slight surface nicking of the wire. This may be obviated by cleaning roughly the ends of the specimen and wrapping them to the extent of about an inch with a single layer of soft tinned iron wire. This is then covered with fluxite and dipped in a small dish of molten solder. Strong end-pieces are made very rapidly in this way. The heat of the solder bath is not high enough to damage patented wire.

The Strength of Braided Wire.—In comparing the strength of individual rope wires before braiding with that shown by them in an ordinary rope specimen which had been broken in a tensile test, one would be apt to expect some distinct inferiority in the wires of the latter after they had been so much deformed and overstrained.

The conclusion come to by the writer, after taking a large number of broken test pieces of new rope, untwisting them, and then testing the individual wires, and comparing the results with the pre-braiding values, was that there was practically no difference between the two cases as regards tensile strength.

Combined Tension and Bending.—A wire in a straight loaded rope sustains tension, and is also bent to various curvatures. Now when a cylindrical rod of length l and radius r is bent to a radius of curvature R, the elongation of the outer fibres is δl, so that $\frac{\delta l}{l} = \frac{r}{R}$. This is a measure of the strain, and in the theory of structures this value is assumed to be so small that the elastic limit is not passed. But if the radius of curvature of a wire in a strand or rope be calculated, it will be seen that this limit is far exceeded, in fact that a large permanent deformation is produced even with new wire, and in a straight rope. Accordingly it is unreasonable to apply the ordinary bending equation deduced for elastic beams to this case, as is usually done, and to say that the stress in the outer fibres of a wire in a rope coiled on a drum of radius R is

$$\frac{w \operatorname{cosec} \alpha}{\pi r^2} \pm \frac{E r}{R}$$

where w is the load on the wire, r its radius, $\pi/2 - \alpha$ the angle of the lay, R the radius of the drum, and E the modulus of elasticity (Young's modulus). It is also incorrect to use this formula for the stress in the curved wire of a straight rope under tension.

The writer carried out a number of what he called "wheel tests" to discover the effect due to curvature. The instrument used was an addition to an ordinary testing machine. A number of cast-iron wheels were turned, of various radii, and with a shallow flat groove on the rim of each. The surface of the grooves were made as smooth as possible and the radii of the wheels were found. The wheels could be slipped on a spindle on which they were free to turn. This was fastened to a flat steel holder. The wheels were rapidly interchangeable so as to vary the radius of curvature at will. A frame was attached to the uprights of a small vertical Olsen testing machine and on this a vice was fastened. The holder was put into this, so that the wheel was vertical in position and also tangential to the axis of a straight specimen in the machine. The wire to be tested had one end F held in the upper fixed jaws of the machine and was taken round the wheel W and had the other end held in the jaws attached to the ram M. A diagrammatic view of the arrangement is shown in Fig. 5. When the load was put on, the specimen was in tension, but the curved part had also the strain due to a known curvature similar to what would occur even in a vertical loaded rope. The forces introduced are, of course, quite distinct from those considered in the frictional effect of coiling a rope or wire round a post, since the wheel is free to turn.

The wire broke on nearly all occasions at the point P, where the curvature began, but, unless the curvature were very great, at a load very little less than that of the straight wire. Sometimes when the radius of curvature had its larger values the wire broke in the straight portion instead of at the beginning of the curve, showing that the introduction of theoretically high bending stresses had little effect on the breaking load of new wire.

Some of the results obtained are shown in the accompanying diagram (Fig. 6), in which the strengths of three patented crucible steel wires are plotted against the corresponding curvatures, *i.e.*, the reciprocals of the radii of curvature in inches. The large value of d/D, where $D = 2\rho$, as compared with permissible strain in structural steel should be noticed.

For a range $0 < d/D < 0{\cdot}03$ failure in the wire may occur in the straight part and not where the extra stresses due to bending are introduced. This is important when comparing the behaviour of wire in ropes with results deduced from the accepted theory of bending.

Note on a Formula Used for Determining the Stress in Rope Wires due to Coiling.—A formula which has been used considerably for this purpose is $\sigma = \frac{E d}{2 R}$, where σ is the stress, R the radius of the drum and d the diameter of the rope. E is taken as Young's modulus for wire, strand, rope, or cable as the case may be, and in the three latter cases it is got from that of a wire by multiplying it by k, k^2 or k^3 respectively, where k is usually taken to be about 0·6.

This equation being derived from that for the bending of an elastic rod $\left(\frac{p}{y} = \frac{M}{I} = \frac{E}{R}\right)$ should not be used for a rope. A bent elastic beam, which springs back into its original shape when the bending forces are removed, differs widely from a coiled inelastic rope which under similar conditions does not spontaneously straighten itself when left on its drum. Also, as M is small for coiling a rope, the ratio M/I would not be equal to E/R, and further, $\frac{d}{2R}$ is not the strain. The treatment, too, of Young's modulus is incorrect, and even if this equation were used the change of curvature for a wire is not 1/R.

To determine this change of curvature, however, consider again a one-strand rope. Let the radius to the outer layer of wire be a, the angle of the helix α. The radius of curvature of a wire in the outer layer when the rope is straight is $\rho = a \sec^2 \alpha$. If the rope be coiled round a drum of radius R we may consider that any convolution has become a torc (or anchor-ring) with the principal radii of curvature a and $R + 2a$ at the outer rim. Hence by a theorem in the curvature of surfaces, the radius of curvature of a wire in this outer layer, making an angle θ with the axis of the drum, or with $\pi/2 - \theta$ as the angle of lay, is given by the equation

$$\frac{1}{\rho} = \frac{\cos^2 \theta}{a} + \frac{\sin^2 \theta}{R + 2a}$$

Putting $\theta = \alpha$, we find the change of curvature for the outer wires of the one-strand rope in the form

$$\frac{1}{\rho_1} - \frac{1}{\rho_2} = \frac{\operatorname{Sin}^2 \alpha}{R + 2a}$$

More experimental data with regard to the bending of ropes is necessary before a satisfactory formula for the stresses set up can be framed.

Manifestly the practical requirement is that the change of curvature should be as small as possible, or in other words that the radius of the drum should be as large as possible. This has been recognised for a long time, but as practical limits are promptly imposed on the radii of drums and pulleys, various empirical rules have been given for the sizes of pulleys, crane sheaves, and winding drums, as the result of extended observations on the duration of life of winding and haulage ropes. In the case of drums for deep winding $D \not< 50\,d$ and $D = 100\,d$ have been suggested, where D is the diameter of the drum and d that of the rope.

Flexibility.—In this connection flexibility tests of winding ropes would be of value, as these might easily be listed in makers' catalogues. A very simple method would be somewhat as follows: Clamp the specimen in a vice at V, and mark off a length, say $l = 50\,d$, where d is the greatest diameter of the rope. Put a loop of cord at B and by it pull the specimen into a semi-circle, holding it thus by the hook of a spring balance. The spring balance reading will enable comparisons to be made between the flexibilities of different types of rope.

This may be done without apparatus by merely taking O V = O A = O B where O is the centre of what is approximately a circular arc, but actually a form of elastic curve, Fig. 7.

If a true semicircle be preferred in order to better represent a pulley, the following arrangement would be adopted. Semi-circles V A are set out as shown, on a board. Holes are made at intervals along the arcs and pegs placed in them, so forming rapidly a cylinder of the required radius. Friction between the rope and board is minimised by a carriage, or by a suspensory arrangement. The spring balance reading is taken as before.

Combined Tension and Torsion.—The writer also made some experiments on combined tension and torsion. These were on mild steel galvanised wires of diameter about 0·05 in. A lathe was dismantled, and its bed extended to about 10 ft. The movable headstock was set at the far end, and the hand wheel operating the barrel was used to give extension to the specimen. To the barrel and to the end of the mandrel were fitted strong isosceles triangular frames, attached by the bases, and with the vertices pointing outwards towards each other. Two wire-drawers' grippers were obtained, and the ends of the handles softened and bent into hooks suitable to slip into the triangular attachments. The arrangement is shown diagrammatically in Fig. 8. S is the specimen, T_1 and T_2 the triangular attachments, G_1 and G_2 the grippers, D a dynamometer for recording the load, M the mandrel and H the headstock. When the hand wheel was rotated the barrel moved to the right in the figure, and the load was applied through the dynamometer to the specimen. Hence tensile stress in the specimen was obtained. In order to relieve the wire from the weight of the grippers and connecting links, an overhead frame was made, parallel to the lathe bed. On this frame little carriages could slide, with cord attachments and counterweights, to balance exactly the weights of the hanging parts. These were thus floated, and the specimen relieved of their weights. The torsion was applied by revolving the mandrel, and graduations on it allowed the angle of twist to be read. The combined effect was obtained by putting on a load through the hand wheel to any desired amount, as read on the dynamometer, and then rotating the mandrel through any desired angle. When a load was taken approaching half the breaking load a small torsional strain produced fracture. This took place suddenly, though the material was ductile. The fracture showed nothing of the "cup and cone" of mild steel in tension, but was a perfect wire torsion fracture, square across the specimen.

This sudden failure in combined tension and torsion was in contrast with the slow failure of the same wire in tension. It was mentioned that in a tensile failure the crack generally begins at the centre, and with ductile material spreads somewhat slowly outwards. With combined tension and torsion the greatest stress is in the outermost fibres, so that failure would begin at the circumference of the circle and would spread immediately over the right section. This was borne out by the appearance of the specimens.

A contributory cause in the specimens tested was the fact that they were galvanised. This would weaken the outer fibres for torsion, as galvanising is known to form a layer of hard and brittle alloy. This effect, however, must be small, as galvanising does little to reduce the number of twists sustained by P.C. steel wire.

Effect of Damage on New Wire.—Some experiments were made to test the effect of local damage to patented crucible steel wire both as regards tension and torsion. Some of the wires were dented under pressure, and others were cut by circular and equilateral triangular files of known dimensions. The cuts were small, so as to be comparable with what occurs in rope practice, and their lengths were read by a microscope. Some of the results obtained are indicated by graphs, Figs. 9 to 12. These show that great deterioration occurs owing to slight local damage. The effect in torsion is particularly marked. The results shown are for new patented crucible steel rope wire.

In Fig. 9 a circular file of diameter 0·153 in. is used to make a circular cut in P.C. (patented crucible) steel wires of diameters 0·115 in. and 0·104 in., respectively. The strength of the damaged wire is plotted against l, the length of the chord of the cut in millimetres. For very short lengths of chord it will be seen that the damage is slight, but it soon increases rapidly with the cut.

Fig. 10 shows a corresponding test made with an equilateral triangular file instead of a circular one. The effect of the damage is much more marked in this case owing to greater localisation of stress.

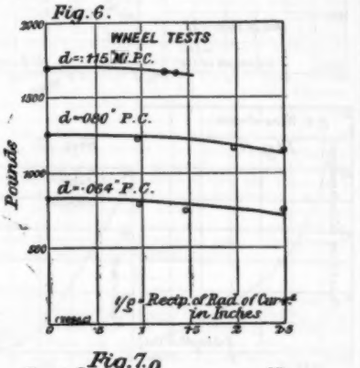
In Figs. 11 and 12 the sensitiveness of a damaged wire in torsion is shown. In Fig. 11 the cut is made with the same circular file as was used in Fig. 9. The number of twists per 50 diameters is plotted against the chord l of the cut. It will be noticed how rapidly the number of twists falls off.

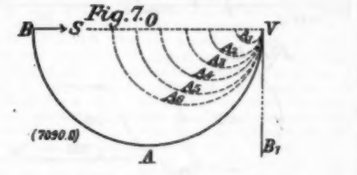
Fig. 12 shows a similar test when the cut is made with an equilateral triangular file. The number of twists in 8 in. is plotted against the chord l of the cut. The falling-off is even more rapid than in Fig. 11.

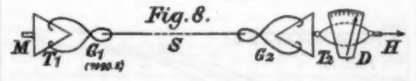
The effect of general as apart from local damage was also tried. A P.C. wire, 0·104 in. diameter, 80/90 tons, 1,560 lb., 27 twists in 8 in., was strained in tension to breaking point, to find the effect of this on the torsions. The result was to show that the change was scarcely appreciable in new wire. On the other hand, when this wire was strained to death in torsion it was still found able to sustain nearly three-quarters (0·73) of the original breaking load. This latter wire was of course in a hard and cracked condition, useless for practical purposes. The former wire that had been broken in tension was little affected, as it had undergone the equivalent of a very slight drawing, mostly local.

Damage to Rope Wires under Working Conditions.—Two of the mechanical causes of weakening in the case of rope wires under working conditions are abrasion, and grooving or denting. Corrosion and its causes are beyond the scope of the present paper.

Abrasion.—When wire has been for some time in a rope which has been used for winding or haulage it begins to be damaged. The outer wires get abraided and the inner surfaces become dented or grooved by pressure and rubbing at the points of contact. By abrasion material is removed at the crowns or knuckles of the wire, and in time the outer periphery of the rope approaches more and more to a cylindrical shape. The crowns of the wires are worn for a considerable length, and are also flattened. Hence the less prominent crown of the Lang's Lay is of distinct advantage. If the section of the wire be considered, the damage done in







the middle stage of the life of an outer wire is greater than the proportion of material removed. In a winding or haulage rope damage is rarely allowed to continue to the fracture of the outer wires.

Grooving or Denting.—The fracture of rope wires is also hastened greatly by grooving or denting. This produces considerable weakening of the inner wires, as well as damage to the inner surface of the outer wires. As the layers of a strand are usually wound in opposite directions, the wires cross each other at the points of contact at twice the angle of the lay. Their relative movements wear grooves at the points of contact, which are accentuated by the pressures due to the normal reactions of the curved wires. Grooving is seen chiefly in a rope which has been in use for some time, but it may be visible in the wires of a perfectly new patented crucible steel cable after a single tensile test.

Ordinary grooving is caused by the pressure and rubbing of wire upon wire, causing interpenetration, but there is another form of grooving set up by the wear of strand upon strand. The deformation of the wires of a worn rope is seen in a striking manner by filing a smooth cross section, when the section of the wire core of a strand may often be seen as a system of hexagons.

So long as a rope is in active use the abrasion and grooving must increase continually, and so the strength of a steel rope, particularly at those places where it passes round a pulley, must decrease continually from these causes. Even a small amount of surface damage causes a considerable weakening in the wire, as it not only destroys the skin at that point, but also localises the stress to the bottom of the groove, so producing early failure.

How much damage a working rope wire may receive is shown in the accompanying Fig. 13, which illustrates the result of only nine months' wear on a first-class P.C. wire in a tramway rope. The wire was originally cylindrical, and its diameter was 0·115 in. The carbon content was 0·53.

The dents or grooves in worn rope wire are nearly elliptic in outline. This may be seen by considering two wires of radius a interpenetrating to the small depth ζ, and having the angle θ between their axes. The observed curve as projected on the xy-plane is a quartic, with a somewhat lengthy equation, which, for the small values of x and y which occur actually, becomes the ellipse $(x \sin\theta - y\cos\theta)^2 + y^2 = 2a\zeta$, the direction of whose axes bisects the angles between the wires. When the wires are at right angles the ellipse becomes a circle, as is seen on putting $\theta = \pi/2$. If r be its radius, then $r^2 = 2a\zeta - \zeta^2$, or since ζ is small, $r^2 = 2a\zeta$, a result also shown by the equation of the curve. The value of r is read easily by the microscope.

Hardness of Rope Wire.—For examining to what extent rope wire becomes hardened through age and work some modification of the Brinell test seems desirable. For making the dent the writer suggests a hard (undeformable) cylinder of the same diameter as the wire. This would be laid upon the test specimen and at right angles to it. The dent would then be formed by pressure as in the usual Brinell test. The writer found that if it were made by the kinetic energy of a falling weight the period of impact was too short for the material to flow properly. The writer got satisfactory results from a simple device like a huge pair of nut-crackers, in which the pressure on the specimen was applied by moving a weight along the upper graduated arm. His attempts to get perfect cylindrical penetration of patented crucible wire by further hardening a piece of the same wire were unsuccessful, as might have been expected, so he was obliged to use both pieces in the ordinary condition. For these hardness tests the two pieces of wire are laid so as to cross at right angles before the pressure is applied. In this case the dent contour curve becomes a circle, as has been shown. In the interior of this contour the wire surface is somewhat flattened. For hard wires the pressure divided by the area of the circular contour could be taken as the hardness number.

If soft wire be tested by denting with a hard cylinder under pressure the dent may become deep, so that the above formula would be unsuitable. A better method would then be to take the pressure divided by the volume of the displaced metal. The latter, however, is more difficult to calculate as it necessitates an elliptic integral. This is a case where the expression under the square root is easy to expand and integrate term by term. Thus the elliptic integral is easy to evaluate.

Effect of Age and Wear on Haulage and Winding Ropes; Haulage Rope.—Comparative tests of P.C. wire ropes were made when new and after nine months' severe haulage.

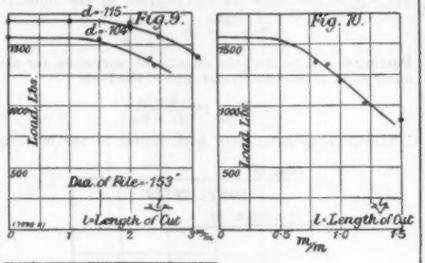
Through the kindness of the Edinburgh Tramway engineers the writer has received samples of tramway ropes after being in use for periods from two to fifteen months. These were made by leading wire rope manufacturers, and the ropes resemble one another in many details. The writer has received from some of the makers information as to the tests of the wires and ropes in their original condition. He then tested the worn wires.

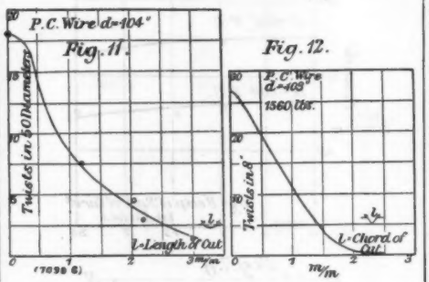
As full details are lengthy, a single typical example will be abridged and cited to show how a haulage rope deteriorates in active use. This rope (No. 35) ran for nine months in an Edinburgh district after which a sample was taken and the wires tested by the writer. From figures supplied the original length was 26,900 ft., circumference 3½ in., formation six strands about a main hemp core. It was of Lang's lay, and of patent crucible steel, special acid grade. The strand was formed of eight wires of diameter 0·115 in. round six of 0·066 in., round a central wire of 0·066 in.

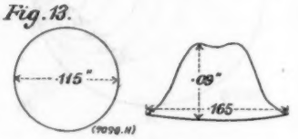
The details of the wires, taken an the average, were as follows:—Outers, diameter, 0·115 in.; strength, 1,725 lb., or 74·5 tons per square inch; twists per 8-in. length, 29. Inners: Diameter, 0·066 in.; strength, 720 lb., or 94 tons per square inch.; twists per 8-in. length, 48. Aggregate of wires, 50·5 tons; breaking load when rope was new, 45·4 tons.

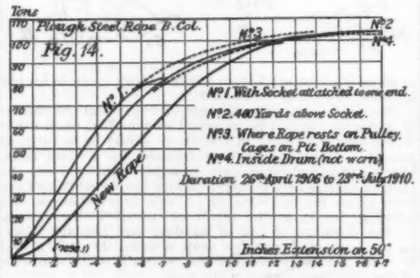
The wear upon the tramway ropes is extremely severe, partly due to the passage over so many pulleys, but especially owing to the friction of the grippers. The amount of deformation of the outer wires after nine months' use may be seen in Fig. 13, which represents the cross-section of an outer wire of this rope at a crown. In addition to the removal of metal by abrasion, it had flowed considerably under pressure. The cold work had hardened the outer skin where the wire had been deformed, and had made it brittle near the crowns. Grooving was very distinct and deep.

As the result of age and wear the average strength of the outer wires was reduced to 1,370 lb. During the tests fracture of course always occurred at the crowns. The average strength of the inner wires was 620·5 lb. This is still a large fraction of the original tenacity in both cases, but the brittleness due to the cold work on









the outers must not be lost sight of. The torsions of the outer wires had fallen for 100 diameters from 41·7 when new to 2·55, due chiefly to the abrasion at the crowns. The torsions for the inner wires per 100 diameters fell from 39 to 17. In this case the local damage was due to grooving. Local damage alone, however, does not account for everything.

The strength of the rope had fallen to 36·2 tons, while that of the aggregate of the wires had fallen to 41·3 tons. The respective efficiencies were:

$$\text{Ef}_1 = \frac{45{\cdot}4}{50{\cdot}5} = 90 \text{ per cent.}$$

$$\text{Ef}_2 = \frac{36{\cdot}2}{41{\cdot}3} = 88 \text{ per cent.}$$

Metallographic Examination.—The metallographic changes at the hardened periphery were very slight, both at low and at high powers of the microscope, showing that the hardening is almost sub-microscopic even at 1,500 diameters. The ferrite, however, at the hardest parts tended to fine down, and be incorporated into the sorbite. No other microscopic change was noticed.

On annealing the wires, and examining again under the microscope, the usual annealed structure was seen, but no change could be detected between the body of the wire and what had been the hardened edge.

The writer considers that the result of a tensile test alone on a sample removed from a working rope might give a misleading idea of the strength and possible duration of a rope in service. He considers that torsional tests of the wires from time to time would give a good idea of its probable durability, and of the stage of deterioration which it had reached.

Winding Rope.—Fig. 14, in the previous column, was constructed by the writer from certified data. It exhibits graphically the change in the properties of a winding rope due to work and age. It also shows comparative values for four different portions of the worn rope, and may throw further light on a very controversial point.

The rope was by a well-known maker, and was particularly successful. It was used in what is believed to be the deepest shaft (3,300 ft.) in England, and ran for two years and ten months. It was of plough steel, and was 4·7 in. in circumference. The construction was six strands round a central hemp core. Each strand consisted of nine wires of diameter 0·124 in., round nine of diameter 0·071 in. round a core wire of 0·142 in.

Too much reliance should not be placed on any single test, especially as plough steel does not always give the results expected. It will be seen that the portion near the socket (1) is the weakest by a considerable amount. The extension of this portion is small and the appearance of the curve suggests fatigue. There is strikingly little difference in strength between the other three samples, viz., the portion (2) 400 yards above the socket, the piece (3) where the rope rests on the pulley with the cages at the pit bottom, and (4) the unworn, but aged, specimen from the drum. The crowns of No. 2 were considerably worn and those of No. 3 slightly worn.

It will be noticed that, in this case at least, the portions which have undergone bending over the pulley are less weak than the socket end, and have a greater extension. The portion of the old rope which is unused has altered in condition owing to age, and in this case is scarcely distinguishable as regards strength from the worn rope.

Fatigue Tests.—The importance of a fatigue test for metal has been recognised for a long time, but till lately there was no simple and fairly rapid method of carrying out such observations. In the Haig alternating stress machine manufactured by Messrs. Brunton, Musselburgh, the cycle of stress is given by the reciprocating movement of an armature, energised by two-phase current; the oscillations being helped by a powerful spring. Curves are plotted from the observations obtained, the abscissa x representing cycles, or millions of cycles, and the ordinate y the stress, or range of stress. When the specimen remains unbroken after some millions of cycles under the highest range of stress that the specimen can stand, the fatigue limit is said to be reached.

Whatever method may be employed for fatigue testing, and whatever machine may be used for obtaining the observations, these are representable finally in the form of a curve, and from this curve the fatigue limit is deduced.

From a mathematical point of view this leaves something to be desired; as one cannot infer mathematically this limit value from such data. It should be obtained from the equation of the curve, but this is unknown. Many curves could be fitted to the data which would give zero as the fatigue stress, infinite and negative values being inadmissible. If a fatigue limit other than zero exists, the curve should have an asymptote parallel to the x axis, but at first glance there seems no reason why such a curve should be assumed. It is suggested that the following consideration helps to answer this difficulty.

If the data be read not merely from the punctual, but from the gradient point of view, a curve is required passing through a known point on the y-axis with a negative gradient, which decreases in scalar value to zero as x increases from zero to infinity. Such a gradient function of x may be obtained easily to fit the observed values. Integration introduces an arbitrary constant, which, when determined from the data, gives the fatigue stress, the integrated function vanishing when x is infinite.

As a rough illustration the following values were taken for the curve given for mild steel in Messrs. Brunton's pamphlet:—

x (millions of cycles)	0	0·5	5
y (half the stress range in tons per square inch)	25	14·5	13

Assuming as the simplest form such a function as

$$\frac{dy}{dx} = -\frac{a}{(x+b)^2}$$

we have, on integrating

$$y = c + \frac{a}{x+b}$$

in which the integrated function vanishes when x becomes infinite. This has only three constants for the fitting. Normal equations for observations such as the above are hardly necessary. On substituting, we have:

$$y = 12{\cdot}82 + \frac{0{\cdot}983}{x + 0{\cdot}0806}$$

which gives a limiting maximum stress of 12·82 tons per square inch.

The position of the intermediate point has little effect on the ultimate value of y. If (1, 14) or ($\frac{1}{2}$, 15) had been chosen from the data given by the curve the corresponding equations would have been respectively

$$y = 12{\cdot}7 + \frac{1{\cdot}43}{x + 0{\cdot}116} \text{ and } y = 12{\cdot}8 + \frac{0{\cdot}6452}{x + 0{\cdot}0532}$$

which give almost exactly the same fatigue stress.

Better but more complicated functions might easily be selected and fitted if required.

The writer considers fatigue and age important considerations in the deterioration of winding and haulage ropes.

PHYSICAL SOCIETY OF LONDON.

At the meeting held on October 28, at the Imperial College of Science, Professor Sir W. H. Bragg, president, in the chair, a paper entitled "*On the Use of Anderson's Bridge for the Measurement of the Variations of the Capacity and Effective Resistance of a Condenser with Frequency*," was read by Mr. S. Butterworth, M.Sc.

An analysis of the effect of residuals and earth capacities in Anderson's inductance-capacity bridge was made, and it was shown that if balances were obtained (*a*) by balancing the bridge with direct currents; (*b*) by making the alternating current adjustments by means of a small series resistance *s'* and parallel condenser C' in the condenser arm; then the changes required in *s'* and C' to hold the balance at different frequencies were equal and opposite to the variations of the effective (series) resistance and capacity of the condenser with frequency. The assumptions made in obtaining the above conclusions were that the residual inductances and resistances of the "non-inductive" arms of the bridge were invariable with frequency, and that the resistance of the inductive arm varied as the square of the frequency. No knowledge of the absolute values of the residuals, &c., was required for the method. The method was illustrated by results obtained with a condenser of capacity 0·5 μ F, and details were given showing how the chief experimental trouble, viz., drift in direct current balance, owing to temperature variations, might be overcome.

Professor Fortescue, referring to the typical results for the change in effective resistance of a condenser given in Part IX of the paper, remarked that telephone engineers usually assumed that the power factor of a condenser was constant, and would be specially interested to see that this assumption was incorrect. He inquired as to the type of condenser used.

Dr. D. Owen congratulated the author on his valuable contribution, and expressed a belief that his methods would be adopted as the standard practice. It would be of interest to apply them to types of bridge other than that of Anderson. He asked if a sufficient number of condensers had been tested to determine whether the frequency coefficient of mica condensers was a definite quantity, or varied from one condenser to another like the temperature coefficient.

Mr. Butterworth's reply will be communicated.

A paper, entitled "*Notes on Earth Capacity Effects in Alternating-Current Bridges*," was read by Mr. S. Butterworth, M.Sc. It was shown that an earth capacity acting at any point in the arm of a bridge might be replaced by two earth impedances acting at the ends of the arm together with an impedance in series with the arm. By integration the result was extended to small distributed capacities. Two methods were given for the elimination of the error due to the end impedances. Complete elimination could only be obtained by the use of shields connected to the ends of the bridge arm.

Dr. A. Russell remarked that the paper contained much valuable matter and called for close study. He questioned whether it was justifiable at such high frequencies to lump the residuals or to leave mutual capacity out of consideration. In the examples given, *e.g.*, in Part VI of the paper, nothing was said as to the distance from earth of the conductors whose earth-capacity was under consideration. Electrical engineers were much engaged upon the problem of protecting telephone circuits from disturbance by power circuits, and found that the mutual capacity of such circuits was far more important than their mutual inductance.

Mr. Guild referred to the method of measuring earth capacity by doubling the error, described in Part III of the paper, and asked whether it was legitimate to assume that the capacity in question was unaffected by the operation of altering the connections.

Dr. D. Owen remarked that the paper showed that standard resistances were subject to errors due to earth capacity. Presumably standard inductances would be similarly affected.

Professor Fortescue stated that in testing at frequencies of 20,000 ~ or 100,000 ~, errors of 10 per cent. were common. Would the proposed methods apply to such tests and make it possible to reduce this error?

Dr. Rankine referred to the disturbances due to external agencies, such as motors, which were heard in thermionic valve amplifiers. Would the author's researches make it possible to determine points in the apparatus, such that by connecting them to earth the disturbances referred to could be eliminated?

Mr. Butterworth's reply will be communicated.

A paper entitled "*An Automatic Voltage Regulator*," by Mr. F. G. H. Lewis, was read by Mr. J. W. T. Walsh, who gave an experimental demonstration. The paper described a method by which automatic voltage regulation to 0·15 per cent. might be obtained for such purposes as the operation of photometric standard lamps on an ordinary outside supply varying by as much as 10 per cent. The lamp was placed across an unbalanced Wheatstone bridge of which two opposite arms were composed of tungsten filament lamps. The increase of resistance of these lamps, due to the extra current passing through them when the outside voltage rose, caused a shift in the balance of the bridge such that the voltage across the photometer lamp remained unaltered, if the values of the resistances in the arms were properly proportioned. The power taken was about 40 times that used in the regulated circuit.

Dr. Rayner suggested that the apparatus described might afford a new type of standard E.M.F.

Mr. F. E. Smith dissented from the view of the previous speaker, and showed that the voltage which was to be kept constant was in fact a function of the resistance of the non-incandescent arms of the bridge. It could thus never be possible in such an arrangement to secure an absolutely constant voltage, such as would be required for the purposes of a standard.

Professor Fortescue said that the method produced a distinct gain in steadiness of voltage and would undoubtedly be appreciated in testing work.

Mr. Walsh, in reply, referred to Fig. 2 of the paper, which showed candle-power plotted against supply voltage. The curve was very flat-topped, thus permitting of steadiness within very close limits, even for variations of supply voltage which would be considered as very large.

A paper entitled "*The Flow of Viscous Liquids through Slightly Conical Tubes*," by Professor A. S. Hemmy, Government College, Lahore, was taken as read, in the absence of the author. A formula was obtained for the flow of a viscous liquid through a slightly conical tube by neglecting terms containing the square of the obliquity. The approximation was found to be justified by the agreement in the values of the viscosity found experimentally with tubes of differing degrees of conicality.

Purification of Mercury.—Mercury which has become contaminated with other substances is generally cleaned either by distillation or by filtration, combined if necessary with a treatment of the mercury with nitric or chromic acid to oxidise other metals present. Both these methods fail in the cases of tin and lead, which Professor C. Harries (*Zeitschrift für Angewandte Chemie*, 1921, page 359) removes by the following operation: The mercury is heated for several hours up to 150 deg. C. in a large flask, while blowing air into the mercury through a glass tube extending about 1 cm. below the surface of the metal, which is kept well agitated. A scum of oxide collects at the surface and is filtered off; the treatment is then repeated until no further scum is formed. A final purification by distillation follows. The scum may contain small globules of mercury which are recovered by digesting the scum with hydrochloric acid. The process is not new, but apparently little known.

The Uselessness of Unpriced Catalogues in China.—It is extremely difficult to induce British and native buyers in China to take any interest in catalogues in which no prices are given. We have often drawn attention to this point, and it is raised again by His Majesty's Commercial Counsellor at Shanghai (Mr. H. H. Fox, C.M.G., F.R.G.S.) in his annual report on the commercial and economic situation in China. Mr. Fox recently found an opportunity of showing some new illustrations of an appliance for cleaning the interiors of large buildings to a firm holding the contract for the heating and sanitary arrangements of a six-storeyed office building in course of erection. The Chinese owner of the new offices was interested at once, but the contractor was unable to give even an approximate idea of the cost of the plant. He has telegraphed for an estimate, but it is unlikely that the United Kingdom company will be able to quote by wire, and more than likely that the owner's enthusiasm will have evaporated by the time the matter is again presented to him, which is characteristic of the Chinese. In this case neglect to furnish full particulars of their plant and an estimate of its cost has in all probability lost an order which, in addition, should have proved a valuable advertisement and led to profitable business.

Strengthening of Zinc and Zinc Alloys by Compression.—The dearth of copper during the war forced the Continental Powers to look out for total or partial substitutes for this metal, and several papers on these attempts and researches have recently been brought before the Deutsche Gesellschaft für Metallkunde. In one of these communications Dr. Ing. Hanszel, of Berlin, deals with the mechanical amelioration of brass and of zinc by compression. Various brasses containing about 60 (from 57 to 61) per cent. of copper, about 1 per cent. of lead and about 3·5 per cent. of total impurities were improved by compression after reheating; but they were not sufficiently uniform to be quite reliable. Zinc containing about 1 per cent. of lead, with traces of iron and cadmium was so much strengthened by high compression that it appeared almost a different metal with its grainy, partly fibrous structure. Compression of zinc had been in use in the Hohenlohenhütte, Silesia, before the war. The ingots should be perfect, the tops and pipe must be discarded, and the ingot re-melted before compression; cracks in the ingot are not really welded up by compression. When objects like stoppers with threaded bolts are pressed in the moulds, sharp corners should be avoided, and the profile rounded-off first and finished on the lathe; the zinc flows, and the lines of flow are diverted at sharp corners. The superior qualities of this compressed zinc are moreover confined to the temperature range 0 deg. to 50 deg. C., but the metal seems to bear the winter cold well. Storage for several years did not deteriorate several of the alloys of zinc with copper and aluminium, which also passed the repeated gauge tests. Among these the alloy of zinc with 6 per cent. of copper and 5 per cent. of aluminium found favour in Austria and was, later, with only 2·5 per cent. of aluminium, manufactured also at Spandau. Zinc alloys with up to 30 per cent. of Al were also tried, and the alloys were tested in large quantities, both mechanically and metallographically. These metals and alloys were mainly utilised in ammunition works.

EXPLOSION OF A CAST-IRON STEAM CHEST.

The Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, has issued a report on a preliminary inquiry held into the circumstances and cause of an explosion of a steam chest which occurred on December 4, on board the steam trawler Canossin, owned by Mr. Richard Watson Lewis, Inchgarth, Pitfodels, Aberdeenshire The vessel was in the Victoria Dock, Aberdeen, at the time, and James Wilson, the second engineman, was killed.

From the examination and report made by Mr. W. L. Mennie, of the Board of Trade Surveyors' Office, Aberdeen, we learn that the chest was made of cast iron and served a dual purpose, viz., for the conveyance of steam to the propelling and auxiliary machinery, and as a safety valve mounting containing two spring-loaded valves, adjusted to lift at a pressure of 168 lb. per square inch. It was connected to the steam dome of the boiler by a branch, the bore of which was 4¼ in., and the external diameter 5½ in. The chest had two other branches, one to which the main stop valve was bolted, and to the other the steam pipe for conveying steam to the auxiliary machinery.

The Canossin was the ex-German fishing vessel Paul, built by G. Seebeck, Geestemunde, in 1894, but, whether the chest that failed was the original one supplied to the vessel, had not been ascertained. No repairs to the chest appeared to have been carried out. It was inspected, by the owner's superintendent engineer and the insurance company's surveyor, on April 29, 1920, when it was opened out. It was seen under steam by the superintendent engineer and the Insurance company's surveyor on October 21, 1920, when the safety valves were adjusted. The vessel, including the chest, was insured with the United Kingdom Steam Tug and Trawler Insurance and Indemnity Association, Limited, Aberdeen.

When the accident occurred a hissing noise was first heard, and the explosion immediately followed, accompanied by a loud report. The chest fractured around the branch at the neck of the flange connecting the casting to the steam dome of the boiler. The chest was displaced a distance of 3½ in. from its normal position, and through the opening thus formed the boiler steam was discharged into the engine-room.

The primary cause of the explosion was the existence of a previous crack in the casting, and was contributed to by the following:—

1. The boiler was free to move slightly in a fore and aft direction.
2. The fillet at the junction of the branch and the flange by which the chest was attached to the boiler was insufficient.
3. No vertical ribs were provided at that part of the chest.
4. The casting was overhung and inadequately supported.

In his "general remarks" Mr. Mennie states that the Canossin was formerly the German fishing vessel Paul, and was sold by order of the Prize Court. She was purchased and taken possession of by Mr. Lewis on March 16, 1920, after which she was overhauled and fitted out as a British trawler. She was registered at Aberdeen under the Merchant Shipping Act, 1894, and commenced fishing operations in October, 1920. On the arrival of the vessel in the Victoria Dock on the day of the explosion the engines were stopped and Wilson, the second engineman, was in charge of the machinery, the steam pressure at that time being 150 lb. per square inch, and the fires low. When the order to start was given the explosion occurred, and on investigation it was found that the chest had failed as stated, and that Wilson had been killed.

After the explosion the chest was inspected and the flange was removed from the dome of the boiler. On making an examination of the chest it was observed that there were four fractures, all of which appeared to have originated at different periods. Number 1 extended from a bolt hole to the outer circumference of the flange; it was oxidised and had the appearance of having been broken for some considerable time, probably when the casting was last jointed to the boiler. Supporting this opinion was the fact that the face of the flange was spigoted, and also that the jointing material used was of the corrugated ring type. Number 2 was also oxidised, and was undoubtedly an old fracture, but apparently it was of slightly more recent date than Number 1. Number 3 was the portion of the casting that failed at the time of the explosion. It was not oxidised, and was obviously a new fracture. Both numbers 2 and 3 had been exposed to the action of the escaping steam, and were, therefore, somewhat discoloured. Number 4 was broken when the flange was removed from the dome; it was clean and bright, and showed that the material had been of good quality. It had also been of considerable assistance in comparing the appearance of the fractures. Number 2 was situated in the upper portion of the branch, and although the crack might not have been readily detected when the boiler was cold, yet it appeared, Mr. Mennie states, reasonable to suppose that there would be at least a slight escape from it when steam was raised in the boiler. None of the persons examined, whose duty it was to detect such an escape of steam, appeared to have seen or heard it, but the mate, James Reid, stated in his evidence that he had noticed a "fizzing" noise, and that five days before the explosion the third hand told him that the second engineman had put a coal bag over the chest to deaden the sound of the escaping steam. Mr. Reid further stated that he saw the bag in place between the upper dome of the boiler and the safety valves. The third hand,

Alexander Ross, had denied emphatically that he had had a conversation with Reid about the chest either before or after the explosion, or that he had any knowledge of anything being wrong with the casting. The first engineman opened the main stop valve on the morning of the explosion, and he also had stated that he heard no sound of escaping steam. Mr. Mennie says that he is satisfied that neither the superintendent engineer nor the insurance company's surveyor was aware that a crack existed in the chest previous to the accident. It may be noted, the surveyor adds, that the failure was preceded by a hissing noise, apparently caused by the crack extending and opening, and was not the sudden and complete failure which would have taken place had a sound casting been torn apart.

The boiler was supported by two vertical plate stools, riveted to the ship's floors, and provided with the usual angle bars, but these stools were not braced or stayed. Two pitching chocks were fitted: one at the forward end and one at the after end of the boiler. After the explosion it was seen that the boiler was touching the forward chock, but was half an inch from the after chock. It is clear, therefore, the report states, that when the ship was pitching, the boiler would probably vibrate in a fore and aft direction, and the stress set up by such vibration would be taken up by the pipes attached to the chest, and by the chest itself at its point of attachment to the boiler dome. There was only a very small fillet at the flange by which the casting was attached to the boiler, and the branch-piece was not provided with ribs from the flange. The lack of a substantial fillet, and of ribs on this part of the chest, undoubtedly showed poor engineering practice. The casting was overhung, and being without adequate support would be subjected to vibration when the safety valves lifted. These three latter contributory causes of the explosion were, however, not in themselves sufficient to have caused failure.

The reason why the chest failed at the particular time of the explosion, the report states, appears obscure. It was clear, however, that owing to the crack referred to above, as Number 2, and the severe weather experienced by the vessel on the previous day, the condition of the chest was such that only a slight shock was needed to complete the failure.

In his "observations" with regard to the surveyor's report, Mr. Carlton, the engineer-Surveyor-in-chief, states that the chest was of sufficient strength for the boiler pressure alone, but in view of the absence of webs between the flange secured to the boiler and the body of the casting, and the limited thickness of the body at that part, it would seem that, in designing the chest no consideration was given to the possible effects of the variable bending and racking stresses which would inevitably be set up by the movement of the steam pipe and the vibration of the ship and machinery. "It also appears to have been possible" (Mr. Carlton adds), "for the boiler to move to a greater extent than is desirable; and this would necessarily, by throwing greater stresses on the chest, hasten the formation of the fractures by which it was gradually weakened until it failed.

"The various defects, mentioned in the report, which led to the explosion are capable of easy rectification and there should be, with the experience now obtained, little risk of a recurrence of a similar failure.

"The material damage was not extensive, but it is," Mr. Carlton concludes by saying, "regretted that the second engineman was unfortunately killed."

Action of Sulphur on Cement in the Tropics.—The earthenware pipes of the Colombo sewage system, laid down within the last fifteen years, are of the improved Stanford type joined by cement and sand in the proportion 1 : 1 with a waterproof ring of "galanack." This material is a mixture of sulphur, tar and oil, and has a crystalline structure and a biscuit fracture when fresh. In some of the older pipes, which had cracked, longitudinally and circumferentially, the cement had turned into a whitish putty, and the galanack had also altered. Examination of these products, according to Dr. Alexander Bruce, of the Laboratory, Colombo, in a recent issue of the Journal of the Society of Chemical Industry, shows that the sulphates had increased whilst the lime, iron, alumina and silica had decreased. The sulphur in the galanack had evidently been oxidised, and the sulphate had decomposed the cement, causing the pipes to crack. The humid heat had accelerated these changes; mineral samples containing pyrites have been observed to change into sulphate and sulphuric acid in the laboratory, where the temperature is 80 deg. F., while it rises to 90 deg. in the sewers.

Asbestos Construction Materials.—The British Chamber of Commerce in Brazil states that it has received a number of communications with reference to the qualities of asbestos manufactures for building purposes. These materials can be used not only in walls and partitions, but also for flooring, roofing, &c. As a substitute for brick they have the advantage of being very rapidly handled and, being obtainable in large slabs. Not only can they be put in place quickly and without any great demand on the skill of the workman, but also there is no delay in the finishing processes. It has been pointed out that they are particularly suitable for such buildings as will be required for the coming Centenary Exhibition (to be opened next year), and in addition to being suitable, an important saving of time would be effected by their use. These materials are also excellently adapted for use in a hot country, as they do not absorb heat as brick, stone or concrete do. A number of British makers are now turning out these materials in great quantity, and they are becoming increasingly popular as experience is gained of their qualities. It is interesting to note that they have already been used and found very satisfactory in Rio de Janeiro.

CATALOGUES.

Water Power Valve.—Messrs. Glenfield and Kennedy, Limited, Kilmarnock, send a catalogue describing the Johnson-Boving valve for use on pipe lines in water power plants.

Machine Tools.—Messrs. Alfred Herbert, Paris, send copies of their French journal *L'Atelier Moderne*, and of their French list of machines in stock, with prices and descriptive particulars.

Electrical Industry.—A copy of a monthly journal, the *Westinghouse International*, with several instructive articles on the electrical and kindred industries, is to hand from the Westinghouse Company, East Pittsburgh, Pa., U.S.A.

Hydro-Electric Line Pipes.—Messrs. Sulzer Brothers, Winterthur, Switzerland, send a very handsome series of views of various pipe-line installations they have supplied for conveying water to turbines for electric power production.

Drop-Forging.—Drop-forging equipment, lay-out of machines, tools, renewable parts and accessories, are all very completely dealt with in an excellent catalogue of 80 pages issued by the Brett Patent Lifter Company, Limited, Coventry.

Carbon Tool Steels.—Messrs. Edgar Allen and Co., Limited, Sheffield, send a useful 8 page catalogue, explaining in practical terms the work for which carbon steel is sufficient and giving directions for ordering, forging and tempering it.

Boilers.—A series of vertical and horizontal boilers for rapid and economical steam generation is shown in a catalogue issued by Messrs. Spencer-Bonecourt, Limited, Hitchen, Herts. Gas and oil-firing and the use of waste gases are specially dealt with.

Boilers.—Small vertical steam boilers in 18 sizes, ranging from 1 nominal horse-power to 20 nominal horse-power, are described and listed, with prices and particulars, in a catalogue issued by Messrs. Herbert Morris, Limited, Loughborough.

Drop-Forgings.—Messrs. Thomas Smith's Stamping Works, Limited, Coventry, send an interesting booklet illustrating examples of the more difficult kinds of drop-forgings and containing useful discussion as to when it may be advantageous to use these in preference to castings.

Electric Motors.—A handsomely-printed illustrated catalogue giving a detailed specification of their standard motors has come to hand from Messrs. Higgs Brothers, Sandpits, Birmingham. Each of the principal parts is separately illustrated and the material and construction fully described.

Cast-Iron Pipes.—A copy of their usual monthly list of cast-iron pipes in stock ready for despatch, including spigot and socket pipes with either rough or turned joint surfaces, and also flanged pipes and hydraulic piping comes from the Stanton Iron Works Company, Limited, Nottingham.

Tube Fittings.—A 360-page catalogue of malleable iron tube fittings comes from Edward le Bas and Co., Dook House, Billiter-street, London, E.C. 3. Thousands of pieces are illustrated covering all standard screwed and bolted connections, bends and branches for pipes in all standard sizes.

Grinding Machine.—A small hand traverse grinding machine with a surface grinding table in front and a cutting-off wheel at the rear is made by the Caplin Engineering Company, Beaconsfield-road, Willesden, London, N.W. 10, and is described in a catalogue received from this firm.

Marine Turbine Gears.—A booklet describing their marine reduction gears, and more especially dealing with the erection and care of the gears on shipboard, which has been issued by the Power Plant Company, Limited, West Drayton, Middlesex, will be of great practical interest to marine engineers.

Fuse Plugs.—Fuse plugs made of alloys which melt at 120 deg. F., or at any higher temperature in steps of 10 deg., and fitted with various indicating devices, are the subject of a small pamphlet received from Messrs. B. R. Vicers (Leeds) Engineering Company, Limited, 17, Tooks-court, Cursitor-street, London, E.C. 4.

Oil Engine Locomotive.—A powerful oil-engined locomotive, very suitable for contractors' work, having four coupled wheels, a tractive effort of 1,200 lb., and three speeds up to 7½ m.p.h., is described in a catalogue received from Messrs. Blackstone and Co., Limited, Stamford, one of the associated firms of the Agricultural and General Engineers, Limited.

Small Tools.—The catalogue of drills, reamers, milling cutters, saws, files and other tools which the Sheffield Twist Drill and Steel Company, Limited, Summerfield-street, Sheffield, have forwarded, will be welcomed because of the full range of sizes included, and also because of its convenient arrangement. In this catalogue drills with straight flutes and with three and four spiral flutes are listed in many sizes.

Ventilation.—Several installations for purifying, heating or cooling the air in workshops and large buildings are illustrated in a catalogue received from Messrs. Simon-Carves, Limited, 20, Mount-street, Manchester. The construction of parts is also shown, with some useful descriptive matter. The illustrations clearly show the advantages as regards expense, appearance and convenience of installing a complete system.

Air Heaters.—A system of air heating and washing of standard sectional construction and applicable to any required increase of temperature, within ordinary limits, is illustrated in a small catalogue issued by the Blackman Export Company, Limited, 374, Euston-road, London, N.W. 1. The use of heat from steam, waste gas, various refuse fuels, and ordinary coal, is provided for, and the complete system is worth careful attention where a supply of pure warm or hot air is required.

Temperature Regulators.—A catalogue describing instruments and fittings for automatically regulating the temperature of living rooms and workshops, as well as of liquids and chambers used in manufacturing processes, has been issued by the Steam Fittings Company, Limited, West Drayton, Middlesex. Fuel-saving, of course, enters into the argument, but there is actually a much greater saving owing to the maintenance of suitable working conditions. More attention might well be given to these matters in factories.

Electric Motors.—Where the use of electric motors, mainly for individual machine drives, and often for small machines, is extending rapidly, it is difficult to select the most suitable and economical type for a given purpose. The Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, send a copy of a pamphlet they have issued to assist in overcoming this difficulty, written in terms which the engineer, without special electrical experience, will readily understand. About 30 electrically-driven machines of widely varying character are illustrated.

Spiral Bevel-Gear Cutter.—Although the action of a machine for cutting spiral teeth on bevel wheels is not very easy to describe, Messrs. Smith and Coventry, Limited, Manchester, have been able to make it clear in about four pages of an eight-page catalogue they have recently issued. A single pair of 4-d.p., 2-in. face bevels, with 39 and 19 teeth, can be cut on their machine in 4¼ hours, of which time half is occupied in machine setting and the other half in actual cutting time. This renders the cutting of small quantities, or even of a single set, economically possible. The photographs reproduced in the catalogue of wheels cut on the machine show a wide range of work.

Swedish-American Press Bureau.—The Swedish-American news bureau, long-planned by the Swedish-American Foundation, has now assumed such definite shape that it may be expected to start operations as early as the New Year, according to *Swedish Export*. The object of the bureau will be to supply the American press with better and more abundant news from Sweden than has hitherto been the case, to spread an increased knowledge of Sweden in the United States of America by special articles about Swedish affairs, and to form a centre of information in America with regard to everything Swedish, and in addition to this to provide the Swedish press with more detailed and more reliable American news and special material of different kinds. With this object an office will be established in New York, in the main centre of activity. An office will be established in Stockholm, where Swedish news will be collected for transmission to New York, and which will distribute to the Swedish press the news received from the New York office.

British Standard Channels and Beams.—In August, 1920, the British Engineering Standards Association issued a new list of British standard rolled steel sections for structural purposes. This list contained particulars of the dimensions of the sections with their areas and weights, but no details of the geometrical properties such as the moments of inertia. The Association has now issued the latter for the beams and channels, and in addition to giving the dimensions and properties in British units, tables have been added to the standard specification showing the metric equivalents of these. It is, however, indicated that the figures in inches and pounds are to be regarded as the standards. In this new list, the symbol "J" has been adopted for the moment of inertia, and the term "modulus of section" has been substituted for "moment of resistance," the symbol "Z" being adopted in place of "R," which was formerly used. The new publication (Report No. 4—1921) may be obtained from the offices of the British Engineering Standards Association, 28, Victoria-street, S.W. 1, or from Messrs. Crosby, Lockwood and Son, 7, Stationer's Hall-court, E.C., price 1*s.* 2*d.*, post free.

Organic Liquids for Thermometers.—Though mercury is certainly the most suitable liquid to be put into glass thermometers, mercury thermometers are expensive. Attempts have frequently been made to use other liquids in factory thermometers in cases where an accuracy of 1 deg. or 2 deg. is generally sufficient. There are various available liquids, but they are not suitable for moderately high temperatures, or they are colourless. When dyed red or blue with aniline colours, the shade of the liquid is either too faint, or the dye is partly decomposed at temperatures approaching 200 deg. C. and loses its colour. Dr. Guido Moeller, of the Reichsanstalt, has recently found that three commercial chemicals, cumol, methylbenzoate and amylbenzoate, can be relied upon for temperatures up to 150 deg., 200 deg., 260 deg. C. respectively, and that they can be dyed with Syrian asphalt to make temperature reading easy. The asphalt is dissolved in the chemical, the solution is filtered, and so much of it is added to the other portion of the solvent as is necessary to impart to the liquid a fairly dark brown colour; that will require about 1 per cent. of asphalt. Extensive trials show that these thermometers are satisfactory within the ranges mentioned.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number o virves given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

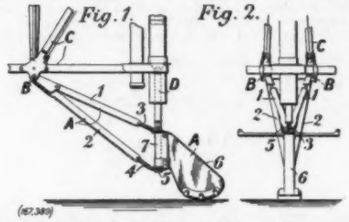
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

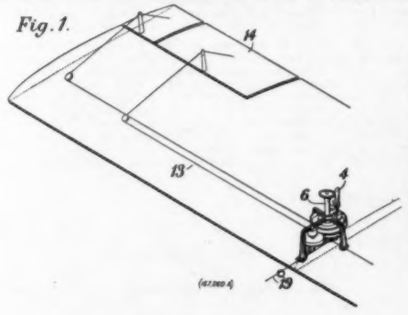
AERONAUTICS.

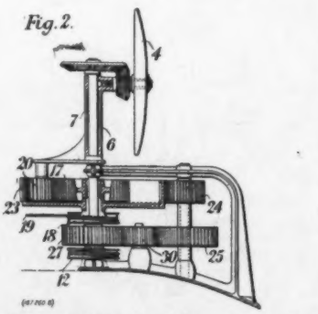
167,389. The Blackburn Aeroplane and Motor Company, Limited, Leeds, and F. A. Bumpus, Brough. Skid Support. (3 *Figs.*) August 3, 1920.—This invention relates to elastically-supported skids for the tail end of aircraft comprising a structure of elongated shape disposed longitudinally of the fuselage of the aircraft, pivoted thereto at its forward end and supported in spaced relation thereto at a point intermediate of its ends by a resilient post or strut extending between the skid structure and the fuselage. According to the invention, the structure A, of elongated shape, is formed in two sections. One section comprises



a triangulated tubular structure formed by two angularly-disposed pairs of tubes 1, 2, each pair of tubes 1, 2 being pivoted at their adjacent ends to one aligned half of the bearing B carried by and disposed transversely of the framework C of the fuselage. The tubes 1 are connected to a lug 3, and the tubes 2 are connected to a lug 4, and the lugs 3, 4 serve to support a substantially-vertical pivot pin 5, the upper end of which is pivoted to the link D. The other section of the structure A comprises a frame 6, of substantially D-shape, forming the skid proper, and this frame is pivoted about the pin 5 and provided with a U-shaped sleeve 7 embracing the pivot pin. (*Sealed.*)

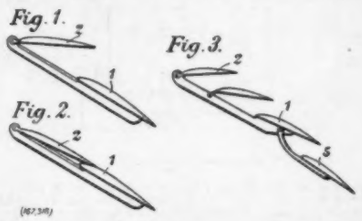
167,260. W. S. Smith, South Farnborough, and G. R. Wilkinson, South Farnborough. Control Gear. (4 *Figs.*) May 3, 1920.—This invention relates to control gear for aircraft of the type wherein a windmill operates the ailerons. According to the invention, a windmill is constructed with fixed blades and is adapted to have its plane of rotation automatically retained in or returned to a position in the direction of motion of the aircraft so as not to rotate, or to be turned by the pilot at an angle to the direction of motion of the aircraft so as to rotate





when required. The windmill 4 is geared to a shaft 7 and can be brought into or out of position to be driven by the air stream. In the operation of the gear, the axis of rotation of the windmill lies normal to the direction of motion of the machine, so that the shaft 7 is not driven. When it is desired to move the aileron 14, the pilot turns the drum 18 by the cable 19, and through the sun wheel 17, planet wheel 20, and annular wheel 23 turns the standard 6, and thereby the axis of the windmill so that its plane of rotation is inclined to the direction of motion of the aircraft, thus causing the windmill to be driven by the air stream. The effect of this is, firstly, to drive the shaft 7, and through the drum 12, to operate automatically the main aileron control 13, and, secondly, through the wheels 27, 30, 25, 24, 23 and 20 to turn the standard 6 until the plane of rotation of the windmill is again in the direction of motion of the machine when the windmill will cease to rotate, while the aileron remains in the new position until the drum 18 is again turned by the pilot. (*Sealed.*)

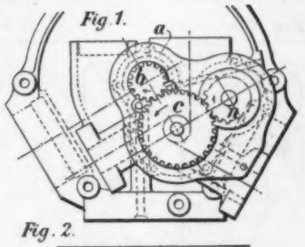
167,318. F. Duncanson, Ealing. Control of Aircraft. (12 *Figs.*) May 15, 1920.—According to this invention, a wing for aircraft has a leading edge part 2 separate from the main structure 1 of the wing, of the same or substantially the same length (*i.e.*, span) as the wing, hinged or pivoted at its leading edge about an axis parallel or substantially parallel to the main structure of the wing. The leading edge part is movable about its pivotal axis. Thus the angle between the leading edge part and the main structure of the wing may be varied at will, or the leading edge part may be closed down to form a single unslotted wing, as shown in Fig. 2. Two or more leading edge parts, all of the same or substantially the same length as the wing, may be



used as shown in Fig. 3. According to a modification, a wing of the normal shape has a leading edge part or parts of the kind described above, and a trailing edge part 5, or a plurality of trailing edge parts disposed one behind the other, of the same or substantially the same length as the wing, each pivoted about an axis forward of its leading edge, which axis is parallel or substantially parallel to the main structure of the wing, and is forward of the trailing edge of the part immediately in front. The edge part or parts is, or are, movable about its pivot, or their pivots, so as to separate them from the main structure of the wing, or close them down to form a single wing. (*Sealed.*)

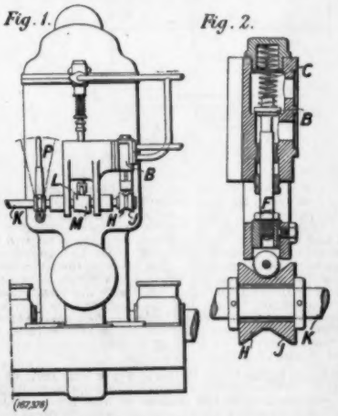
GAS ENGINES, PRODUCERS, HOLDERS, &c.

167,333. J. M. Rubury, London. Lubrication of Internal-Combustion Engines. (2 *Figs.*) May 21, 1920.—This invention has reference to forced feed lubrication arrangements which derive pressure from the toothed wheels operating the valve gear functioning as a pump. The invention consists in the arrangement of an auxiliary chamber *o* on the casing *a* enclosing the



toothed gear *b*, *c* employed for driving the valve-operating gear. The chamber *o* envelopes one or more toothed wheels *n*, of less width than that of the valve-operating gear wheels with which it, or they, engage so as to transmit motion externally to the desired adjuncts without destroying the pumping function of the valve-operating gear wheels. (*Accepted August* 17, 1921.)

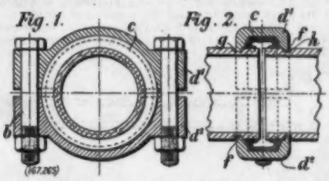
167,376. R. W. Allen, Bedford. Internal-Combustion Engines. (2 *Figs.*) July 15, 1920.—In internal-combustion engines in which compressed air or gas is used for starting and reversing, and in which the air is admitted to the cylinders through



a valve or valves operated by cams, the valve B controlling the supply of compressed air from a reservoir is operated by oppositely inclined surfaces H, J mounted on a shaft K adapted to be moved axially. Pressure is continually exerted upon the valve stem F by means of a spring C, which causes the shaft K to be moved into neutral position when the operating handle F by which the shaft is moved axially for forward running or reversing is released. On the shaft K pairs of cams L, M set for timing the supply of air to the cylinders are mounted. (*Sealed.*)

HYDRAULIC MACHINERY.

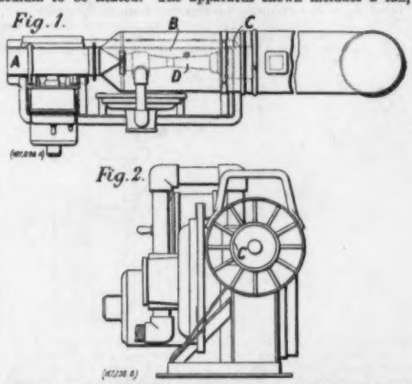
167,265. H. S. Hele-Shaw, London, and E. Tribe, Hampstead, London. Pipe Joints. (3 *Figs.*) May 3, 1920.—This invention has reference to a pipe joint of the kind consisting of a hollow leak-preventing ring of flexible material open to fluid pressure between inturned edges forming its inner periphery, and adapted to engage respectively the adjacent ends of the two pipes of the joint, the outer portion of the ring being closed within a metallic housing, and the invention consists broadly in the provision of mechanical means for reducing the diameter of the leak-preventing ring so as to increase the gripping pressure of its inturned edges on the ends of the pipes. In the preferred form



of the joint, the housing d^1, d^2 is divided longitudinally and provided with bolts *b* for drawing the divided portions together on the leak-preventing ring *c*. The external diameter of the leak-preventing ring is made sufficiently larger than that of its engaging recess in the housing to cause the desired pressure on the ring when the divided portions of the housing are drawn thereon. The housing is constructed with inwardly-extending portions *f* to enter grooves *g* and *h* formed in the outer surface of the pipes near their ends, in order to provide a means for preventing the longitudinal separation of the pipes of the joint. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

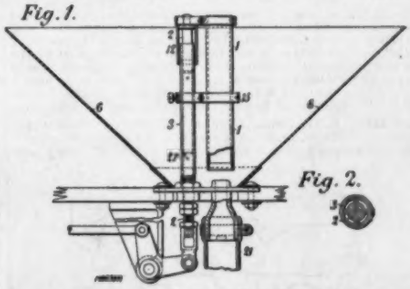
167,236. J. Keith, London, G. Keith, London, and D. B. Bain, London. Drying Moulds. (5 *Figs.*) April 28, 1920.—This invention relates to heating or drying apparatus of the type comprising a trunk, a burner within the trunk, and means for supplying the burner and for moving medium to be heated through the trunk around the burner. According to the invention, the burner is formed as a cup surrounded by fins coolred by the medium to be heated. The apparatus shown includes a fan,



a trunk B coupled to the fan casing A, and a gas burner C within the trunk B, a continuation of which trunk B delivers to the moulds air supplied by the fan and heated by the combustion of gas, and also the products of combustion. The burner C is disposed centrally of the trunk B and is supplied by an injector D. The burner C consists of a cup-like structure lined with refractory material and provided with radiating fins extending between the cuplike structure and the inner wall of the trunk B (see Fig. 2). (*Accepted August* 17, 1921.)

RAILWAYS AND TRAMWAYS.

166,787. J. L. Taylor, Liverpool, and A. E. Taylor, Liverpool. Sanding Rails. (2 *Figs.*) May 10, 1920.—In sanding apparatus of the type in which the sand is held in a hopper container and its discharge is by a tubular valve, the tubular valve is, according to this invention, operated by a rod 2, actuated by the driver, passing up through a guide tube 3 which extends up through the sand container 6 parallel with the tubular

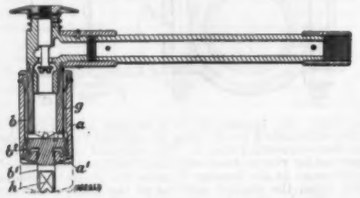


valve 1. The upper end of the rod 2 is secured to the upper open end of the tubular valve 1, and the latter is guided by a ring guide 15 fixed upon the tube 3. By working the rod 2 up or down, the tubular valve 1 is raised or lowered, it being guided by the guide 15. The tube 3 is larger in internal diameter than the rod 2 and the latter is guided therein by two pins 21 passed at right angles to one another through the rod 2 and projecting therefrom at two points. The tube 3 does not extend to the top

of the rod 2 and another tube 12 of a larger diameter is fixed to the upper end of the rod 2 and over-laps the tube 3 in all positions of the valve, and so prevents the sand getting into the rod tube. (*Accepted August* 4, 1921.)

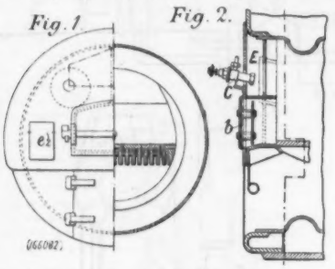
STEAM ENGINES, BOILERS, &c.

166,953. P. G. Handoll, Lewisham, London. Boiler Scaling Tools. (2 *Figs.*) April 22, 1920.—The percussive tool, according to this invention, is mainly distinguished from other percussive tools in that the outer member constitutes the percussive body and is serrated to act as a tool. In previous constructions it is arranged to strike a drill or other separate tool. The improved tool comprises an inner member or piston *b*, which serves as a guide and is held firmly with its front end *b*1 against the tube, plate or other surface during the operation of the tool, and a percussive body *a* mounted to reciprocate longitudinally upon the inner member and formed with cutting edges *a*1 on its forward end. An annular chamber *g* is formed between the inner member *b* and the percussive body *a* to which the pressure fluid is admitted continuously to reciprocate the percussive body. The percussive body *a* is cylindrical in shape



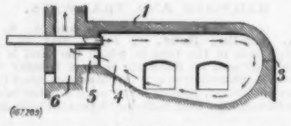
and its ends, which have circular openings and fit around parts *b*1, *b*2 of the inner member of different diameters, constitute the ends of the pressure chamber and are so dimensioned that the forward end presents a larger area to the action of the pressure fluid than the rear end. In consequence of this difference the tendency of the pressure fluid is to force the percussive body *a* forward. Exhaust apertures or outlets provided by forming flats *h* or grooves on the end *b*1 of the inner member *b*, are uncovered by the percussive body near the end of the forward stroke, and the front and rear portions of the annular pressure chamber *g* are separated more or less or communication between them is cut off momentarily by a collar *b*2 on the inner member moving into a part of the chambered interior of the percussive body which fits more or less closely around the collar. (*Sealed.*)

166,082. J. J. Kermode, Liverpool. Liquid-Fuel Burners. (2 *Figs.*) March 22, 1920.—This invention relates to a combined arrangement suitable for the furnace front of a marine type boiler and adapted for the burning of liquid fuel or of coal.



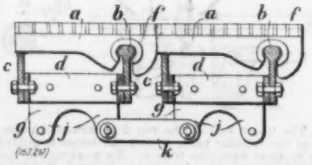
According to the invention, two liquid-fuel burners C are fitted one on each side of, and both above, the coal firing door *b*, the burner nozzles being located in a casing E formed between the furnace opening and the boiler front to which casing air is supplied by non-return air valves *e*2. (*Sealed.*)

167,289. Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw, Manchester, F. B. Trevelyan, Openshaw, Manchester, J. H. Andrew, Openshaw, Manchester, and C. P. Miller, Openshaw, Manchester. Burning Powdered Fuel. (3 *Figs.*) May 5, 1920.—A furnace of the type in which powdered fuel, together with sufficient air for its combustion, are projected along a flat roof 1 and are deflected by means of a rounded end 3 of the furnace so as to travel backwards



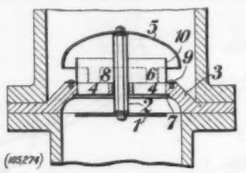
over the hearth whereby the hot waste gases are caused to heat the incoming cold air and fuel and so facilitate combustion, also producing a regenerative effect by giving up heat to the incoming air and fuel by conduction and radiation is characterised by the fact that the furnace chamber is of wedge shape tapering toward the front, which constitutes a comparatively narrow opening 4 at the front, from which the waste gases escape by way of the port 5 into the external flue 6. (*Accepted August* 17, 1921.)

167,217. F. H. Bond, London. Chain Grate Stokers. (3 *Figs.*) March 31, 1920.—A chain grate stoker made in accordance with this invention is characterised in that the grate bars



are slidden on to a pivotal member of bulbous configuration, the bulbous member being adapted to retain the bars in the required position during their travel. The grate surface is formed by a succession of rows of grate bars *a*. Each row of grate bars is carried by a bearer *b* and a supporting member *c*. The bearer *b* and the supporting member *c* stretch transversely and parallel to one another across the furnace, and are rigidly connected together by pieces *d*. Each grate bar *a* has a special-shaped jaw *f* adapted to fit over the bulbous head of the bearer *b* by being slid on from the end. A link-shaped member *g* is rigidly attached to the piece *d*, and is provided with two teeth or horns *j* in such a manner as to form a recess or gap between them to co-act with the teeth of a sprocket wheel. A plain link *k* pivotally connects one member *g* to the next member *g*. (*Sealed.*)

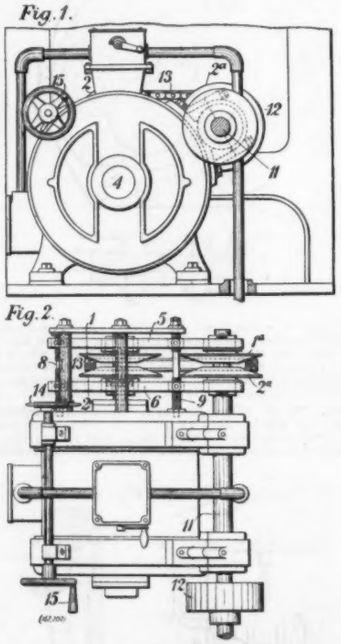
165,274. John Brown and Co., Limited, Clydebank, and W. H. Wood, Clydebank. Steam Turbines. (2 *Figs.*) April 26, 1920.—To control the connection between a high pressure astern turbine and the low pressure turbine exhaust, there is connected to a valve proper capable of limited movement, a canopy located on the opposite side of the seat from the valve proper and, according to this invention, provided with means for limiting the movement of the valve proper in a direction away



from its seat, while also permitting the passage of steam. The valve proper is a plane disc 1 to which is fitted a stem 2 projecting through the diaphragm 3 in which the valve openings 4 are formed and carrying a canopy 5 formed with lugs 6 to prevent the valve proper from being moved more than a predetermined amount from its seat 7. The passage of steam is permitted through the openings 8 formed between the lugs 6. Secured by pins 9 to the diaphragm 3, or formed in one with it, is a ring 10 projecting into the space sheltered by the canopy 5. (*Sealed.*)

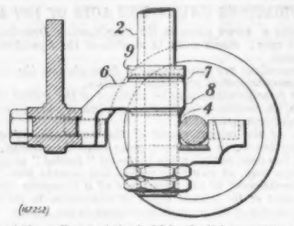
TEXTILE MACHINERY.

167,200. H. H. Wright, Halifax. Ring Spinning Machinery. (2 *Figs.*) January 26, 1920.—This invention provides a variable drive in ring-spinning machinery. According to this invention, there is provided in the form of a complete unit, a constant speed electric motor and variable speed gear of the expanding pulley type regulated from the machine or by hand by rotating a right and left-hand screw which operates two levers arranged to expand and contract the pulleys. The two portions 1, 2 of a conical pulley are slidably mounted on the motor shaft 4 and connected with two levers 5, 6. The levers 5, 6 are coupled together by two right and left-hand screws 8, 9. One of the screws, namely 8, is situated at one end of the levers and the other at a point intermediate of the two ends. The opposite



end of each lever carries a ball thrust bearing and a portion of a cone pulley 1*a*, 2*a*, that is slidably mounted on a shaft 11, which is coupled to the tin roller shaft through a centrifugal clutch 12. The two conical pulleys are geared together by a belt 13 and the screw 8 is connected by gearing 14 with some moving part of the machine which will impart to it the necessary variation in speed for regulating the speed of the tin rollers, as may be required. When the screw 8 is rotated, it causes the levers 5, 6 to turn on their fulcrums, with the result that the two portions of one cone pulley approach one another, whilst the two portions of the other cone pulley recede from one another. In addition to the screw 8 being controlled automatically from the machine, it may be actuated by turning the hand wheel 15. (*Accepted August* 17, 1921.)

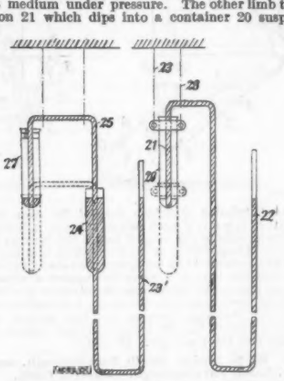
167,252. J. L. Rushton, Bolton. Flyer Frames. (1 *Fig.*) May 1, 1920.—The invention relates to means for facilitating the setting or adjustment of the spindles of flyer frames and like spinning machinery, and more particularly to the snugs carried by the rail of a fly frame and which snugs carry the spindles thereof. According to the present invention, the upper and lower bearing surfaces 7 and 8, respectively, of the snug 6 are constructed of conical tapered or bevelled formation, as shown, and the usual flange 9 upon the lower end of the long collar 2 is furnished upon its underside with a recess adapted to fit upon the tapered or conical part 7 of the snug 6 with a certain amount of play between the bottom of the recess and the bevelled end 7 of the snug 6, as shown by the dotted lines. The underside 8 of the snug 6 is similarly formed to the upper bearing surface 7,



as shown, and the collar 4 of the bobbin shaft bearer 5 is provided with a recess and the parts are so arranged or adjusted that the conical or bevelled surfaces 7 and 8 take the load, and a space is left between the upper and lower sides 7 and 8 of the snug 6 and the bottoms of the recesses so as to allow for the "play" of the parts and for the wear and tear thereof. (*Sealed.*)

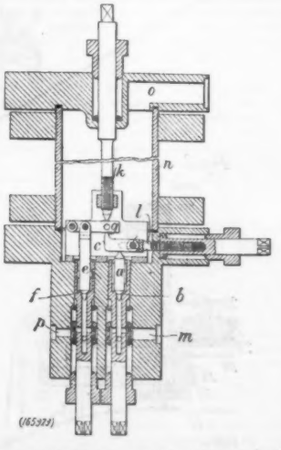
MISCELLANEOUS.

165,988. Kelvin, Bottomley and Baird, Limited, Glasgow, and M. B. Field, Glasgow. Pressure Gauges. (4 *Figs.*) April 24, 1920.—A pressure gauge particularly applicable for indicating the depths of liquids, according to this invention, comprises a U-tube 22, one limb of which is coupled to a source of gaseous medium under pressure. The other limb terminates in a syphon 21 which dips into a container 20 suspended by



springs 23. The container 20, syphon and U-tube are filled with mercury which, when the U-tube 22 is coupled to the source of pressure, is forced into the vessel 20. The quantity of mercury forced into the vessel 20 is dependent on the pressure of the gaseous medium; the vessel 20 descends and the extent of movement is recorded on the chart. Or, as illustrated in the left-hand portion of the illustration, the second limb of the U-tube terminates in a reservoir 24 into which dips a siphon 5 connected to move with the container 27. (*Sealed.*)

165,929. Sir A. S. Haslam, Derby. Compression Refrigerating Apparatus. (2 *Figs.*) March 29, 1920.—The multiple effect receiver of a compression refrigerating apparatus working on the "multiple effect" system has two expansion valves or cocks controlling the inlet from the condenser to the receiver and the outlet from the receiver to the evaporator, respectively, arranged so that they may be simultaneously adjusted at one operation. The one valve *a* is held on its seat *b* by a lever *c*, and the other valve *e*, parallel to the valve *a*, is held on its seat *f* by lever *g*. The movement of the valves *a*, *e* is adjusted by a



regulating screw *k* which engages with the lever *g* whereby both valves can be adjusted at one operation. The valves are shown held in the closed position by the screw *k*, which is turned to allow the valves to lift. The pivot of the lever *c* is carried by a screw rod *l* by which the pivot can be moved so that the ratio of the opening of the two valves *a*, *e* may be varied. Fluid from a condenser enters through a passage *m* and passes the valve *a* to a receiver *n*; the gas formed passes away through an outlet *o* to a compressor and the liquid passes the valve *e* to the outlet *p* leading to the evaporator. (*Sealed.*)